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MENTE ET MALLEO ATQUE CATINO*

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INTRODUCTION

The title of this address has not been chosen with the purpose of creating the illusion of classical erudition. Two-thirds of it was found ready-made, as most of you will recognize, on the seal of the organization for concerted effort in geology, The International Geological Congress; the other third I have added in order to emphasize my conviction that the motto, expressive of an all too common attitude, suggests but inadequately the desirable activities of geologic science. It ignores experimental attack upon the problems of the science. To observe and to attempt to reach conclusions based on the observations is not enough; we must also, insofar as may be possible, devise experiments which will test the conclusions. It may indeed be regarded as somewhat surprising that the adopted motto should be thus unbalanced, for the first paper presented before the first session of the Congress, Paris 1878, was entitled "Etudes expérimentales sur les déformations et les cassures de l'écorce terrestre" and represented only one of the diverse investigations of the brilliant genius of experimental geology and petrology, Daubrée. Nor did he labor alone in these fields. However, a motto is not a compendium and it is unquestionably true and will probably ever remain true that geology as a whole is dominantly a science of observation and inference. In those branches of geology with which we of this Society are principally concerned, namely mineralogy and petrology, there is an increasing shift of emphasis. Experiments devised to throw light on the conditions of origin of those mineral aggregates which we know as rocks and mineral deposits, are growing in number and scope. The position may be maintained that, for these branches of geology, experiment has come to be quite as important as field and laboratory observation in evaluating conditions of genesis, and it is this that is unquestionably the fundamental problem of mineral science. Experiment is a necessary check upon inference from observation, whenever experiment is possible, and it is

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an activity that should be more generally pursued, wherefore I say *atque catino*.

If one based his judgment upon present-day emphasis he would unhesitatingly conclude that the fundamental problem of minerals is that of their fine structure. The success of the x -ray spectrograph in revealing crystal structure is astounding and the activities of its devotees are altogether admirable, but the x -ray spectrograph, and, I may add, the petrographic microscope, the chemical balance, and other tools of the mineral investigator, are to be regarded as highly developed hammers. They enable us to observe more closely, and from these more intimate observations more reliable conclusions concerning the origin of minerals may be reached, but they are not primarily a part of that system which would seek to check conclusions by appropriate experiments. It is possible to suppose that, with progress in our knowledge, we may ultimately be able to read in its atomic arrangement and the electronic configuration of its atoms all the conditions that attended the formation of a crystal and also its subsequent history. We would then have a hammer so effective that the crucible becomes superfluous. The attainment of this blissful state is devoutly to be wished and efforts in that direction should be encouraged in every way. In the field of intermetallic compounds, which are, however, fundamentally different from ionic compounds as represented by the most important of minerals, the silicates, it has proved possible to explain the general form of the phase-equilibrium diagrams of some alloys in terms of the number of electrons in the electron shells, and a certain amount of successful prediction may be expected. Recent attempts to correlate the order of crystallization with the crystal-lattice energy of silicates may be steps in the same direction. The reduction of all knowledge in any science, indeed in all science, to a few unifying formulae is a goal ever to be striven for, but the possibility that such formulae may some day be available does not warrant an attitude of watchful waiting in the hope that laborious experiment may be rendered superfluous. Such aspirations inevitably remind me of a condition which prevailed when I first joined the staff of the Geophysical Laboratory. There were then enthusiastic thermodynamicians who wagered that within five years such advance would occur in thermodynamic theory and in the measurement of fundamental thermodynamic quantities for silicates that it would no longer be necessary to determine silicate equilibrium relations experimentally; instead they would be determined by a few simple calculations. Five times five years have passed since those sanguine days yet it is still necessary to determine silicate equilibrium diagrams by means of experiment. Perhaps no more rapid

success will be attained in the prediction of mineral equilibria from atomic and electronic considerations, and it is a knowledge of equilibrium relations that is essential to the determination of the conditions of genesis of minerals, their fundamental problem.

COOPERATION

Thus we are led to view the two great activities of mineral science, apart from interpretation; on the one hand, field and laboratory observation—wielding of the hammer; on the other hand, studies of phase equilibrium—testing in the crucible. Their coordination is a vital necessity to progress in the science, and should be the aim of all earnest investigators. Specialization is nowadays so great that a student must emphasize the one or the other. An individual will naturally seek to enhance the prestige of his chosen branch. His plain course here is to do so through the excellence of his work and not, as is unfortunately done by a few workers in each branch, through the disparagement of activities in the other branch.

Coordination of effort ordinarily takes a form somewhat as follows. An observer has examined certain mineral groupings in field and laboratory, and from his observations upon end-products has reached conclusions as to processes. He then approaches the student of phase equilibria, the tester, and urges upon him the desirability of a study of the relations between the mineral phases involved, the observer thus setting the problem. The chosen investigator may find relations that tend to confirm the conclusions of the observer and then all is merry as a marriage bell. On the other hand he may find relations that throw some doubt upon the observer's deductions and that even suggest another process. Then arises, for each, the temptation to disparage the other's work. Divorce is imminent, but not inevitable, for with the more thoughtful this situation will be only a spur to further effort. Each will reexamine his results to see where they might be improved in quality or extended in scope and will act upon his findings. Thus may eventuate an agreement of conclusions or a closer approach in views. If on the contrary they reach an impasse, much gain will nevertheless result. Each will have a more lively appreciation of the factors involved in the problem. Each will vigilantly seek a more penetrating method of breaking the impasse.

STUDIES IN MINERAL DEPOSITS

As an admirable example of a formal cooperative effort involving these two activities, I may mention the "Secondary Enrichment Investigation," in which a group of geologists combined to study the natural

relations of copper ores by both field and laboratory methods, and a group of chemists combined to carry out coordinate studies of the chemical factors involved in the formation of these ores and especially in their secondary enrichment. It had been concluded by geologists that certain copper ores had suffered enrichment through the agency of acid descending waters formed under surface and near-surface conditions. In the joint investigation the group of geologists reexamined the evidence, greatly extended existing knowledge of the ores, and were able to make additional suggestions as to the probable character of the processes whereby secondary enrichment is accomplished. The group of chemists studied the relations of the sulphides to each other, established the variable chemical composition of chalcocite, the black sulphide which is frequently formed during secondary enrichment, and determined the effect of composition upon the inversion temperature from the orthorhombic to the higher-temperature, isometric form. This latter study especially revealed that chalcocite with more than 8 per cent excess sulphur above the formula Cu_2S , experienced no inversion but persisted in the isometric form upon cooling. A chalcocite with orthorhombic outward form and with less than 8 per cent excess sulphur must therefore have formed below the inversion temperature of 91° . Although chalcocite of isometric outward form has not been found in nature, some massive examples of the mineral show an octahedral etch pattern which, if the excess sulphur is less than 8 per cent, proves their formation above 91° . These indications of temperature of formation are of some assistance to the geologist in reaching a decision as to the hypogene or supergene origin of certain chalcocites.

Of the reactions involved in enrichment itself it was found that copper sulphate solutions change pyrite to covellite and chalcocite, pyrrhotite to chalcopyrite and probably bornite, chalcopyrite to covellite and chalcocite, bornite and covellite to chalcocite, and chalcocite under some conditions to metallic copper, in which reactions a definite stability series will be recognized which accords on the whole with observations on the natural occurrences and confirms the general conclusions reached from them.

The general field of deposition of ore and gangue minerals from solutions is wide open and much can be accomplished in the determination of genetic conditions by investigations of phase equilibrium.

STUDIES IN SEDIMENTARY ROCKS

An outstanding example of the application of laboratory methods to the solution of geological problems lies in the field of sedimentary pe-

trology. It is the classic study of Van't Hoff and his colleagues upon the deposits of oceanic salts. Experiment has also guided interpretation of the factors controlling mechanical deposition and has thrown light on the modification of these factors by chemical effects, as in the peptization of suspensions by electrolytes, though here there is room for much further work.

Such problems as that of the origin of authigenic feldspars in limestones can hardly be brought to final solution elsewhere than in the laboratory. In spite of much investigation, the question of the genesis of dolomite is still susceptible of alternative interpretations and further studies of phase equilibrium are needed, though this may be found to merge with the problems of the metamorphic rocks.

STUDIES IN METAMORPHIC ROCKS

Investigations designed to throw light on the conditions under which various metamorphic rocks acquired their distinctive characters have not been carried far. The mineral associations observed in certain types of hornfels are found to comply with the requirements of phase equilibrium as determined in the laboratory under conditions of direct crystallization from the melt and therefore under conditions of high temperature and low pressure. On the other hand, other hornfels types have contradictory assemblages, showing minerals that are mutually incompatible under the mentioned conditions. Whether this is ordinarily to be referred to failure of equilibrium, or is sometimes, at least, due to a shift of equilibrium under lower temperature and higher pressure conditions are questions that have not yet been solved by experiment. This failure is largely the result of the exasperating slowness of reactions in the solid state and the difficulty of identifying microscopically any new phases formed. With the powerful tool now available, x-ray powder photography, it should be possible to overcome some of these disabilities. Undoubtedly also the attainment of equilibrium, the growth of crystals and the formation of phases not developed in the dry melt can be accomplished by adding small quantities of fluxes, including volatile fluxes, and progress may be hoped for through the application of this method.

Experimental studies of the factors controlling crystal orientation are also desirable. The need is stressed by the much greater prevalence of crystal orientation than had formerly been realized, a condition revealed by the advent of petrofabric analysis. Steps are already being taken by a number of investigators to meet this need and from them we may hope to have a valuable check on the conclusions reached by the observer as to the factors controlling and the processes effecting orientation.

Thus may the crucible, sometimes in the guise of the autoclave or the hydraulic press, aid in the solution of problems raised by the observer of metamorphic rocks.

STUDIES IN IGNEOUS ROCKS

An example of the actual interplay of the two activities is afforded, in the realm of igneous geology, by studies of monomineralic and anchimonomineralic rocks. Here there is no formal cooperative effort of organized groups, but coordinate attack by the two distinct methods is none the less real. The observer finds in the field gabbroic rocks consisting mainly of pyroxene and plagioclase with a little olivine, and frequently associated with them, rocks in which one or another of these minerals is increased in amount, in some instances to such an extent that it is substantially the only mineral present. Since the gabbroic rocks are obviously the product of direct consolidation from a melt of their own composition, it was but natural that the observer should regard all the related rocks as having been formed in like manner and should speak freely of anorthositic or dunitic magmas, without realizing that they present a special problem. But the student of phase equilibrium, working with mixtures of related composition, finds that when his mixtures approach pure plagioclase, especially more calcic plagioclase, or when they approach magnesian olivine, the temperatures of melting became very high. Calcic plagioclases melt around $1,500^{\circ}$, magnesian olivine around $1,800^{\circ}$. He points this out to the observer and asks him what the evidence is as to the temperature of formation of such rocks as anorthosite or dunite. Contrary to the usual case, the mineral synthesist here visualizes and sets the problem. The observer reexamines his rocks and finds little if anything to indicate unusually high temperatures. The synthesist then suggests that perhaps these rocks were not molten as such, perhaps they are just crystal accumulations from gabbroid magma. This suggestion violates all the observer's previous concepts; at first he refuses to consider such a possibility, but when he is reminded of his own observation that there are no lavas of anorthositic or dunitic composition he consents to examine the rocks again. Thus are the suggestions of the thermal investigator tried in the crucible of observation and it is found that many of the examples of these rocks have characters not inconsistent with the concept of their origin as crystal accumulations, but the examination reveals variants of the rocks for which the observer is unable to visualize any method of emplacement except as a liquid.

At this stage informal coordinated investigation of ultrabasic rocks now stands, to use the term ultrabasic in the loose sense signifying anchimonomineralic and related types. It has been and is being carried

on in a most healthy and delightful spirit of cooperation. Geologists have been most assiduous in field and laboratory study of these rocks. They have examined a great many occurrences and have found that in several complexes the principal anorthositic and peridotitic facies are susceptible of interpretation as crystal accumulations. Certain peridotite dikes which, on first acquaintance, seemed to render peridotitic liquid a necessary assumption were found on closer acquaintance to have basaltic selvages, suggesting the possibility that the flow of a crystal mush of peridotitic character was lubricated by basaltic magma. Geologists have also found anorthositic injection gneisses which they are inclined to regard as indicative of the presence of anorthositic liquid, but there remains the possibility that they were formed by reaction between the material of a banded rock and a liquid permeating certain bands of the rock, which liquid may not have been of anorthositic composition. Such an origin of anorthosite is not inimical to the view that there are no anorthositic magmas, though it indicates that the suggestion of origin by crystal accumulation, made as a result of laboratory studies, does not exhaust the possibilities.

However, difficulties accumulate for him who questions the existence of anchimonomineralic magmas. Certain dunitic pipes are found which geologists believe were injected as liquid magmas and they adduce some evidence that the magmas carried at least a little water. Geologists turn also to a study of the serpentines, rocks which are usually secondary after peridotites, and they conclude that some of them are the direct product of consolidation from a highly aqueous magnesia-rich magma.

The older concept of the existence in nature of highly magnesian liquid magmas is thus extraordinarily tenacious of life. Its vitality may be the vitality of truth itself. On the other hand it may be the result of a natural reluctance on the part of the observer to abandon opinions once held. In any case the problem is handed back to the student of phase equilibrium who is asked to determine equilibrium relations of such highly aqueous magnesian magmas, from which determinations it is hoped that suggestions may arise as to how such magmas can come into being. For the very existence of such magmas, if indeed they do exist, presents the special problem of visualizing a process which brings together in the same liquid the most refractory of the common rock constituents, viz., magnesian silicates, and the most common hyperfusible constituent, viz., water, and these to the practical exclusion of all other constituents. The investigator of equilibrium may or may not be able to accomplish the task set before him. He too may suffer from a reluctance to abandon opinions once held and may suggest, before undertaking his task, that serpentine, as a result of its peculiar physical charac-

ters, is probably unusually capable of intrusion in the solid, plastic state especially in *nappe* structures, and that in the meantime the observer examine his intrusive serpentines with this possible mode of intrusion in mind. The condition envisaged would explain the commonly observed lack of contact effects, thermal and hydrothermal, upon adjacent rocks, though it is possible that such effects are not always lacking, if the glaucophane schists associated with certain serpentines are, as has been claimed, of the nature of contact aureoles.

Serpentines with such aureoles are, in any case, highly specialized examples, but it is plain enough from the foregoing discussion that in spite of much investigation the problems of these ultrabasic rocks are far from final solution. Yet it can hardly be doubted that a large body of facts regarding them has been ascertained as a result of the close scrutiny to which they have been subjected, following the suggestion that they may never have been molten as such, but may be crystal accumulations. So progresses our knowledge of these rocks and so must progress mineral science as a whole—*mente et malleo et catino et mente*.

MEMORIAL OF REINHARD BRAUNS

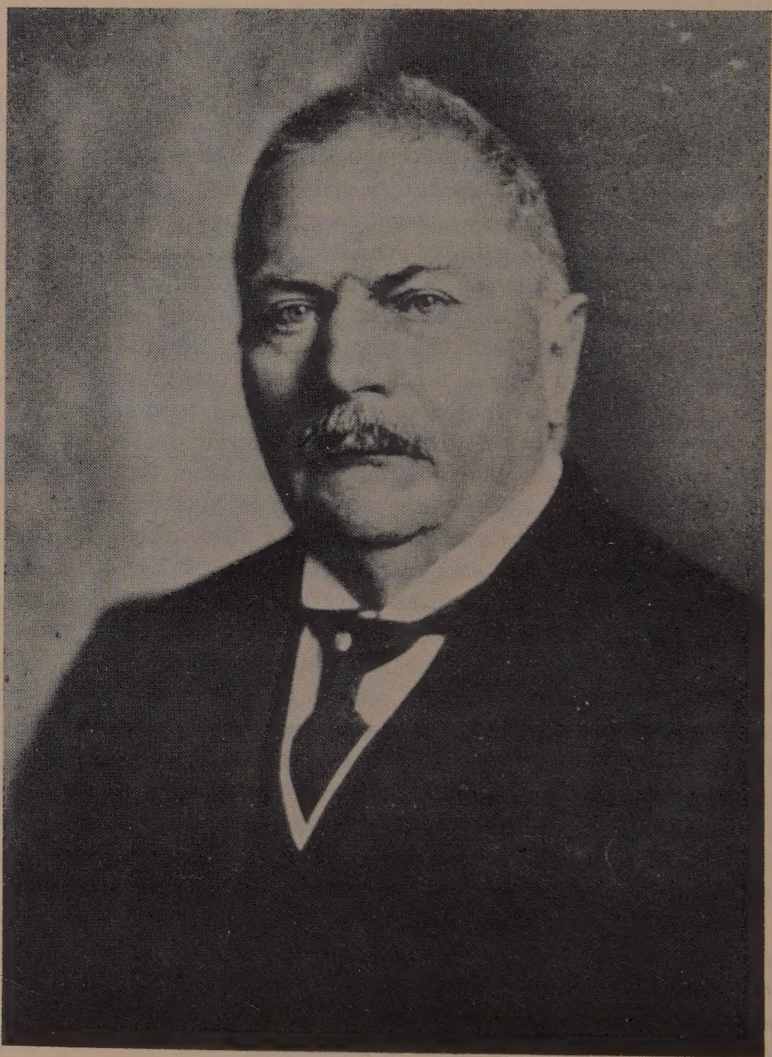
EDWARD H. KRAUS,

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As the result of being run down by a streetcar in his home city, Dr. Reinhard Brauns, for many years Professor of Mineralogy and Petrography at the University of Bonn, Germany, died on January 28, 1937, after eight days of intense suffering. Although he was in his seventy-sixth year, Professor Brauns had been in the best of health, and was, until the very last, actively engaged in mineralogical research to which he had devoted more than fifty-five years. In fact, only an hour before the accident, which proved to be fatal, he finished an article on *The Mystery of Zircon*, which has since been published in the *Deutsche Goldschmiede-Zeitung*. With the passing of Dr. Brauns we have lost another of our great leaders, for he belonged to that group of European mineralogists who contributed so signally to the development and advancement of mineralogy and allied sciences during the last six decades.

Reinhard Brauns was born at Eiterfeld, near Cassel, Germany, August 20, 1861. His early academic life was spent in Marburg, where he attended the Gymnasium and the University from which, in 1885, he received the degree of Doctor of Philosophy. In 1887 he sustained the examinations for appointment as Private Dozent at the University of Marburg where he remained until 1894, when he became Professor of Mineralogy and Geology at the Technische Hochschule in Karlsruhe. A year later, he was called to a similar position at the University of Giessen, which he held until 1904, when he accepted a professorship at the University of Kiel. After three years at Kiel, he began, in 1907, his long career as Professor of Mineralogy and Petrography at the University of Bonn, where he taught so successfully until his retirement in 1934. From 1907 to 1927 he was also an honorary professor at the Agricultural College located in Bonn.

As a scientist Professor Brauns was very versatile, for his numerous contributions dealt with many phases of mineralogy and petrography. Of his publications, which number nearly two hundred, reference will be made only to his classical studies on the optical anomalies of crystals, his excellent treatise on chemical mineralogy, and his many articles dealing with the rocks and minerals of the volcanic areas of the Rheinland and the famous Laacher See district. To these must be added many fundamental papers in which he discussed the properties of gem minerals, for Professor Brauns was long interested in natural and synthetic gems, and sought to cooperate with the gem industry of Germany through frequent visits to the important gem-cutting district of Idar-Oberstein.



REINHARD BRAUNS,
1861-1937

Professor Brauns was, moreover, very skillful in interesting large circles in crystals and minerals, for his excellent and profusely illustrated volume entitled *The Mineral Kingdom*, which appeared in 1903, has been translated into four languages—Italian, Russian, Czech, and English. No doubt, it is safe to say that for over forty years all students in Germany who became interested in mineralogy were familiar with his small and inexpensive elementary book on mineralogy, which was first published in 1893 and of which over one hundred thousand copies of the seven editions have been sold.

In addition to his activities as professor and author, Dr. Brauns had a notable career as editor of the *Neues Jahrbuch* and of the *Zentralblatt für Mineralogie, Geologie, und Palaeontologie*. He served these journals from 1917 to 1934. During this period, in addition to his regular duties as editor, he reviewed and abstracted an exceedingly large number of important articles and books on subjects in mineralogy and related sciences.

The contributions of Professor Brauns and his standing as a scientist were widely recognized, for he was elected to honorary membership in the Mineralogical Society of Germany, of which he was one of the founders, and in the Natural Science Associations of Coblenz, of the Rheinland, and of Halle, and in the Mineralogical Society of London. He was also a corresponding member of the Norwegian Academy of Science of Oslo. In 1928 he was elected an honorary life fellow of the Mineralogical Society of America.

His superior services to mineralogy and higher education were also recognized by his colleagues at the Universities of Giessen and Bonn, for at the former institution he served as Rector in 1903 and at the latter as Dean of the Philosophical Faculty in 1918. Moreover, the University of Bonn conferred upon him, after his retirement, an honorary Doctor's degree. In 1931, upon the occasion of his seventieth birthday, a special volume of eight hundred and fifty pages of the *Neues Jahrbuch für Mineralogie, Geologie, und Paleontologie*, containing forty-three articles contributed by his former students and friends, was dedicated to him.

Professor Brauns possessed an unusual insight into and knowledge of mineralogy and the cognate sciences. As teacher, investigator, author, and editor, he was conscientious and painstaking. As a man and friend, he was very charming and lovable. With many others who were privileged to know him, I shall always cherish the most delightful memories of my friendship and visits with him.

MINERALOGICAL OBSERVATIONS ON THE NORTHERN EXCURSION OF THE XVII INTERNATIONAL GEOLOGICAL CONGRESS

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INTRODUCTION

The 17th International Geological Congress was held in Moscow during the latter part of July 1937. Geological trips to various parts of the Soviet Union were offered to the members both before and after the meetings. The pre-Congress trip of most general interest to the mineralogist was the "Northern Excursion," which began at Leningrad and went northward through Karelia into the Kola Peninsula. The members of this trip felt especially privileged, since it was the first time since the revolution that foreigners have been permitted in that section. This region has long been known for its large number of unusual minerals, and recently, because of the extensive exploration under the Soviets, many new mineral localities have been discovered. Within the past decade it has taken on a far greater significance due to the discovery and commercial exploitation of large deposits of apatite.

The Russians extended themselves to the utmost to make their guests comfortable. At times the accommodations were not what one might expect elsewhere, but all felt that they were given the best the country had to offer. Several of the leaders of the excursions could speak English, and guidebooks printed in both Russian and English reduced the language difficulties to a minimum. The guidebooks were well written and printed on a good grade of paper in small volumes. In writing this paper free use has been made of the two guidebooks covering the "Northern Excursion."*

It is well recognized by the leaders of the present plan for industrialization of the U.S.S.R. that a factor of prime importance is the development of the natural resources. Consequently, geology is a favored science and no expense appears to be spared in furthering its ends. With such governmental support prospecting is frequently carried far beyond the limits that would be considered economic in a capitalistic country. Thus, extensive prospecting may yield nothing of commercial value, but it affords an excellent opportunity for the mineralogist and the student of paragenesis.

* International XVII Geological Congress, The Northern Excursion:

1. The Karelian A.S.S.R.
2. Kola Peninsula.



FIG. 1. Index map of the N. W. portion of the U.S.S.R. The dotted line indicates the route taken by the "Northern Excursion."

KARELIAN EXCURSION

Shunga. The portion of the excursion through Karelia was devoted mostly to a study of the pre-Cambrian. Only three of the older mineral localities were visited, the first of which was Shunga on the west shore of Lake Onega. It was here that the bituminous mineral shungite was discovered nearly 100 years ago and was subsequently mined as a fuel. From the present abandoned appearance of the mine one gathers that the mineral at present has little commercial value, although it is stated in the guidebook that the best varieties can be burned under forced draft.

The workers on shungite have described three varieties based on the amount of carbon. The averages of the carbon content given for the three varieties are: 1 with 92%, 2 with 56%, and 3 with 29%. The varieties 2 and 3 are considered as members of a series of bituminous slates. However, the purest variety associated with calcite, strontianocalcite, and pyrite is believed to have formed by sublimation, or from a liquid solution. These solutions originated by the action of intrusive diabase on the less pure varieties. The most interesting specimens collected at Shunga are calcite veins implanted with small, crystal-like masses of shungite.

Shuyeretskaya. The second mineral locality visited in Karelia was near Shuyeretskaya village on the west shore of the White Sea. Here is found a coarsely crystalline gedrite-biotite-garnet schist as one member in a series of metamorphic rocks. Imperfect crystals of garnet (grossularite, almandite, pyrope), although making up only 5 to 10% of the rock, are most striking, for they vary from half an inch to three inches in diameter. Most of the crystals contain many inclusions, chief of which is cyanite. In addition to the garnet, coarse crystals of cyanite, gedrite, quartz and biotite are also present.

Chupa. For 300 kilometers southeast of Kandalaksha along the west shore of the White Sea is found a series of Archean crystalline schists and gneisses into which granite pegmatites have been injected at fairly regular intervals. These pegmatites have long been known and mining began at an early date for muscovite. In fact, it was white mica from this region that originally received the name muscovite. Altogether there are over forty separate localities where pegmatites of commercial value are known. Of this number, the members of the Congress were scheduled to visit three, but due to stormy weather, saw only two. They were in the Chupa fjord district, where there is not only the greatest concentration of pegmatite veins, but also the largest commercial deposits.

Chupa is located on the railroad at the head of a fjord about 25

kilometers long. A small steamboat took the party down to Ambarnaya Bay nearly at the end of the fjord, where within a short distance of one another are two large pegmatites that have been developed under the Soviet regime. The larger one, the "Samoylovich" vein, is the only one now worked. There the minerals consist of large blocks of pink microcline-micropertthite, quartz, and plagioclase with small amounts of biotite. Other minerals, among which are pyrite, uraninite, magnetite, and calcite, are decidedly subordinate.

The mining methods are very primitive, with even the drilling done by hand; but, in spite of this fact, over 100,000 metric tons of material have been excavated in seven years. Both feldspar and quartz are mined and shipped for use in the ceramic industry; and, since these two minerals make up nearly the total bulk of the pegmatite, there is little waste. The quartz is shipped 3,200 kilometers (2,000 miles) to its place of consumption, and this, coupled with the obvious high cost of hand mining, would make it a very expensive product if judged by capitalistic standards.

The "Eighth March" vein, the other pegmatite visited, is 1.5 kilometers from the "Samoylovich" vein. Here the chief minerals are white microcline and quartz, but a small amount of a purple muscovite of good quality is also recovered. The microcline is present in enormous crystals, the outlines of which can be seen on the wall of the abandoned quarry measuring six to eight meters on a side.

KOLA EXCURSION

Afrikanda. The first locality visited in the Kola Peninsula was Afrikanda, which was of considerable interest to the mineral collector. A pyroxenite body with segregations of titaniferous ores cutting the pre-Cambrian schists is associated with alkaline pegmatites. Within recent years literally kilometers of trenches from one to three meters deep have been dug over an area of about 11.5 square kilometers, and channel samples taken of the bedrock. In this way a fair-sized body of titaniferous magnetite has been developed, although no mining has been done up to the present time. However, in the course of prospecting, a clear picture of the rock relations has been obtained and a score of minerals discovered. All of the exposures visited were those developed by trenching.

The main mass of the body is a fine-grained pyroxenite whose crystallization was followed by the intrusion of a coarse-grained pyroxenite near the central portion. This coarse rock contains rounded xenoliths of fine-grained peridotites with segregations of titano-magnetite and knop-

ite and finely banded melilite olivinites. Due to random orientation of the banded xenoliths, they are believed to be an eruptive breccia older than the pyroxenites and not segregations within it. Numerous veins of alkaline pegmatites cut the complex of coarse-grained pyroxenites and in places have reacted with the older rock, forming a hybrid that approaches the composition of ijolite. Since these pegmatites carry titanomagnetite and knopite and are confined to the central portion of the intrusive, they are considered as formed from the "residual melt of the ultra-basic magma."

The "ore minerals," knopite and titano-magnetite, are found most abundantly as segregations within the xenoliths and as accumulations surrounding the pegmatite veins. In addition, knopite is disseminated through the fine-grained pyroxenites. These two minerals are usually massive and difficult to tell apart, but in places knopite is found in small octahedral crystals.

An extremely interesting rock making up some of the xenoliths is an olivinite carrying over 24% melilite. The melilite is found both as isolated crystals several millimeters in diameter and as dense whitish gray bands across the dark olivine and massive ore minerals.

The alkaline pegmatites are composed mostly of nepheline and pyroxene with schorlomite, knopite and titano-magnetite. The crystallization in places is extremely coarse, for roughly cubical fragments of nepheline from single crystals were found measuring 18 centimeters on a side. In addition to the above-mentioned minerals, prehnite, calcite, and natrolite were found locally and are believed to have been formed during a late phase of the pegmatite development.

With such an abundance of titanium and calcium present in the Afrikanda intrusive, it seems strange that there is so little sphene. It was found only at one locality, where it was in yellow crystals associated with calcite.

The Khibine Pluton. A visit to the Khibine pluton in the central part of the Kola Peninsula was the culminating point of the Northern Excursion. This offered a rare opportunity for the petrographer and mineralogist to see, although in a cursory fashion, a unique petrographic province with its corresponding unusual mineral associations.

The Khibine pluton is composed of a series of nepheline-rich rocks covering an area of 1,327 square kilometers. Due to the greater resistance to erosion offered by the igneous rocks, they form mountains which rise, on an average, 1,000 meters above the surrounding marshy country and present a typical glaciated topography. The Russians use the word *tundra* to refer to the upper treeless portions of the mountains; and,

since all but the lower slopes are above timber line, this area, underlain by igneous rock, is called the Khibine tundra. The pluton is made up of successive injections of igneous rocks, all of which are arcuate in plan resembling great ring-dikes. Six major injections have been distinguished. The oldest is at the periphery in contact with the pre-Cambrian schists, and in general it can be said that, as one approaches the center of the body, successively younger rocks are encountered. The rocks making up the complex (beginning with the oldest) are listed in the guidebook (p. 57) as follows:

1. Alkaline syenites, fine-grained and medium-grained nepheline syenites.
2. Massive chibinites and their vein facies.
3. Trachytoid chibinites and their vein facies.
4. Rischorrites (poikilitic nepheline syenites).
5. Ijolite-urtites, malignites and lujavrites.
6. Massive and trachytoid foyaites; fine-grained and medium-grained, micaceous, aegirite-hornblende-nepheline syenites.
7. Dike complex.

Because of the large size of the pluton and the ruggedness of the country, the opportunity to make a complete traverse from margin to center was not presented. Instead, three separate excursions, in the more accessible parts of the body, gave a composite cross section. Although all the transportation facilities available were placed at the disposal of the Congress, it was necessary to do considerable walking to get a picture of the Khibine tundra. It is a young country in the process of development, and roads are few.

At the Museum of Science and Industry at Kirovsk there is an excellent exhibit of all the minerals found in the Kola Peninsula. There, one can see over 100 minerals found associated with the rocks of the Khibine pluton, of which 17 are species originally described from there. The list is characterized by many zirconium-niobium-titanium silicates. Although on the excursions less than a third of the exhibited minerals were seen, the museum was a good starting point to show the visitor what might be expected in the field. At Kirovsk, as in many other places in the Soviet Union, great care has been taken to enlighten the visitor on the natural history of the region; and one cannot but marvel at the completeness of the exhibits found in a town only seven years old.

An inspection of the Kukisvumchorr apatite mine near Kirovsk was a treat to the geologist and mineralogist alike, and showed Soviet mining at its best. The mine is located on a mountain spur between two glacial valleys in a great lens of apatite-nepheline rock. This sheet-like lens is found at the contact between underlying ijolite-urtites and over-

lying nepheline syenites (rischorrites). It is approximately 4 kilometers long, varies from 150 to 200 meters in thickness, and dips toward the center of the pluton at an angle averaging 67° . With such gigantic proportions, the estimated ore reserve of two billion tons does not seem a gross exaggeration.



FIG. 2. The Kukisvumchorr apatite mine.

The ore body from an economic point of view may be divided into two parts, the upper third a rich zone and the lower two-thirds a poor zone. The following table taken from the guidebook (p. 107) shows the qualitative mineralogical composition of the two zones.

<i>Minerals</i>	<i>Weight percentage</i>	
	Rich zone	Poor zone
Apatite	65	45
Nepheline	20	30
Aegirite and amphibole	10	18
Sphene	2	3
Titanic-magnetite	2	3
Other minerals	1	1
Total	100	100
Percentage of P_2O_5	26-27	16-17

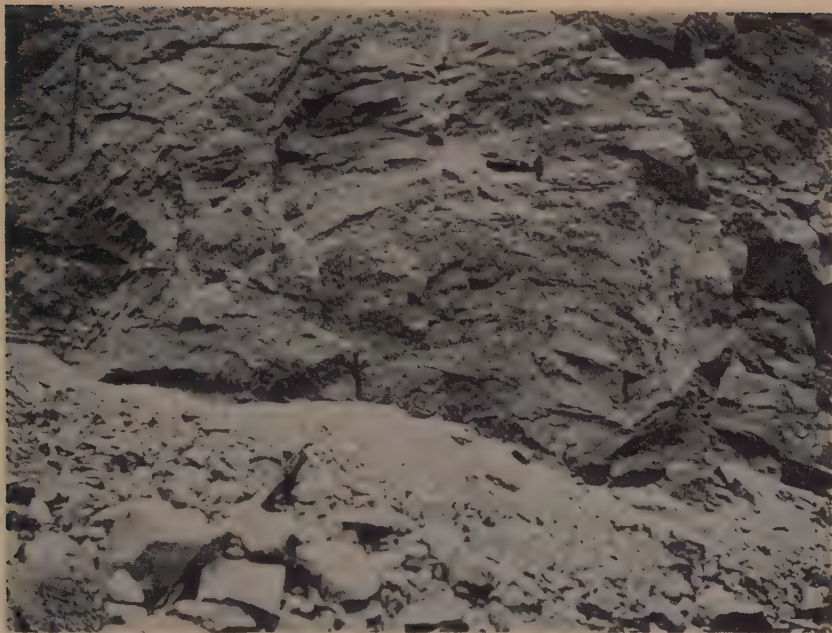


FIG. 3. Mine face showing banding of apatite ore.

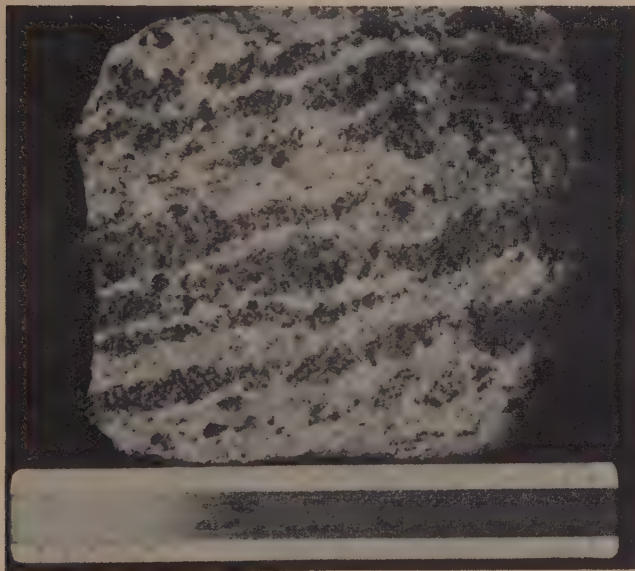


FIG. 4. Specimen of ore taken from the face shown in Fig. 3. The light bands are apatite, the dark bands nepheline.

Six years of mining has produced the great scar on the mountain side shown in Fig. 2. Surface work, however, is being gradually abandoned, and within a few years it is planned to have only underground mining. The chief reason for this change is the long arctic winters that leave only a short period for outside work. At present there are 30 kilometers of underground workings. Those haulage-ways through which the excursion proceeded were large and well lighted, and driven almost entirely through ore. The ore is hauled by electric engines to a central portion of the mine and dumped onto a grizzly over a large glory hole. It is drawn from below into standard-gauge ore cars, and thence transported about 5 kilometers to the mill at Kirovsk. None of the Congress members was permitted within the mill, nor told the milling process. However, it was learned inadvertently that the apatite is separated from nepheline and other minerals by flotation.

The visit to the apatite mine was on "rest day," so no mining activity was seen; but, during the remaining five days of the Soviet six-day week, work is carried on for 24 hours a day. During 1936 about 2,000,000 tons of ore were mined, of which about one-fourth was exported. Charts in the museum in Kirovsk showed that each year Russia supplies more and more phosphate to the other European countries.

Although most of the apatite concentrate is used in making superphosphate in the conventional manner for fertilizer, some of it is ground extremely fine, and used directly with no processing at all. It was stated that, if used in this way, the beneficial effects of the phosphate would last for four years.

Although a booklet has been circulated telling of fifteen different ways that nepheline, the chief tailings product, is used, one of the mine geologists said that most of it is waste.

The apatite in the best grade of ore is a light green, with a sugary texture that stands out in contrast to the dark green, more massive nepheline. Some coarse apatite reaching a grain size of 5 millimeters was seen, but is less common. The most spectacular ore is banded with alternating layers of nepheline and apatite (Figs. 3 & 4). Locally the bands give the appearance of a dome-shaped deposit, but the strike and dip vary markedly from place to place and no generalization as to structure can be made. Other ore has a spotted or mottled appearance caused by segregations of the minerals, while still other is an intimate mixture.

As indicated in Table 1, sphene is a common constituent of the ore, found usually in pinkish masses, but in places is seen in small prismatic crystals. In certain areas a pegmatitic phase with a coarse crystallization of the lesser ore constituents was seen. Large nepheline crystals

and coarse-grained aegirite, aenigmatite, sphene, and eudialite are surrounded by the sugary-textured apatite. A large number of other minerals, including sulphides, lepidomelane, secondary generation aegirite, calcite and natrolite are reported to be found in veins crosscutting the ore body.

Across the valley, east of the Kukisvumchorr apatite deposit is the Yukspor apatite deposit located in the continuation of the great sheet-like lens of ore. Here the excursion followed a prospecting trench up the mountain side across the strike of the ore body, and was thus given an excellent opportunity to observe the changes within it. Near the lower contact, apatite, urtite and ijolite bands alternate with one another making up the low-grade portion of the ore. As one goes higher in the section, the apatite bands are of greater thickness and make up increasingly higher percentages of the ore body. Near the hanging wall is a concentration several meters thick of nearly pure prismatic sphene.

A mine has been opened to work this sphene concentration, and a brief visit to some of the workings gave a cross section similar to that seen on the mountain side. In a crosscut the relations within the ore body were even better shown than on the surface. Here one could observe an increasing content of sphene in the apatite as one approached the hanging wall. There was also a concentration of sphene seen in the overlying rischorrites. Aside from the sphene concentration, the mineralogy is similar to the Kukisvumchorr deposit across the valley.

Little could be learned as to production of sphene. The only information was that the titanium is used in the chemical industry and as a paint pigment.

It is interesting to note that the manager of the sphene mine is a woman and that about half of the laborers, as elsewhere in Russia, are women.

Of considerable interest to foreign members of the excursion was a visit to the Yukspor lovchorrite deposit, where a mine of considerable proportions has been opened to extract this unusual mineral. Lovchorrite is an amorphous silicate of calcium, titanium, and rare earths, and has thus far not been found outside the Khibine tundra.

Lovchorrite has been found in several places within the pluton, but in general it is confined to two arcs; one interior, the other exterior. That of the exterior arc is found in pegmatite dikes within the trachytoid chibinite, and was not seen. The interior arc is located between the rischorrites and foyaites within a narrow intrusive band of aegirite-hornblende-nepheline syenite. The lovchorrite is found in pegmatites cutting this syenite near the rischorrite contact. High on the north wall

of the Lapp valley in a prospecting pit in one of the pegmatites was found lovchorrite, rincolite (the crystalline variety of lovchorrite), pink fibrous sphene, eudialite, feldspar, nepheline, aegirite and zeolites. The concentration here was not considered great enough to be of economic importance.

The section of the interior arc where lovchorrite is mined is in the middle part of Yukspor mountain about 7 kilometers from the apatite mine. The mine, located well above timber line at an elevation of 830 meters, is 180 meters above the village in the valley and is reached by a covered stairway. Work has been carried along an essentially parallel set of pegmatite dikes. Where the dikes approach one another is found the greatest concentration of lovchorrite.

The casual inspection given in the short time available showed the pegmatites to be composed essentially of microcline crystals and coarse aggregates of aegirite. In places, lovchorrite and arfvedsonite filled the interstices between these minerals. Sphene, astrophyllite, apatite and rincolite were also collected, but in minor quantities. Although the number of minerals seen was small, the list of those found in this mine is a long one and includes several found only there.

Even though several piles of ore containing specimens rich in lovchorrite were seen and promptly set upon by Congress members, the appearance of the mine suggests that the average ore must be very low grade. One cannot but wonder whether the rare earths derived from this ore would pay for their extraction, and if Soviet Russia is not the only country in the world where such a mine could exist.

A NOTABLE CENTENNIAL IN AMERICAN MINERALOGY*

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Centennials of notable scientific achievements by Americans have not been frequent. This, in some measure, is due to the relative youth of our civilization. It must also be remembered that during the development periods of the United States and Canada our educational and scientific facilities were very meager. But the period of the 1830's may well be designated as one of emergent science. During those years some really significant contributions were made by our scientists. Such a contribution was the first edition of J. D. Dana's *System of Mineralogy*, which was published one hundred years ago in 1837. During the past century this remarkable volume has constantly grown in strength and influence. Today it occupies a unique place in world science.

It was at the beginning of the 1830's that Joseph Henry made his discoveries of self and mutual induction of electrical currents. In the field of chemistry Robert Hare was active. He was constantly adding to his already long list of important and fundamental observations. Asa Gray, the botanist, was just embarking upon a notable career as one of our foremost scientists. His *Elements of Botany*, published in 1836, marked the beginning of a remarkable series of books. John James Audubon was at work on his famous *Birds of America* and the accompanying *Ornithological Biography*. Both were finished before the close of the decade. Moreover, in 1833 William Beaumont published his observations on the processes and laws of digestion.

It was in this interesting period that James Hall began his long and brilliant career with the Geological Survey of the State of New York. As we all know, this survey was destined to play a most significant role in the development of American geology. The centennial of its founding was commemorated by this Society two years ago, when Dr. Rudolf Ruedemann reviewed its work at the annual dinner in New York. As surveys were also being organized in other states, Merrill has well characterized the decade of the Thirties as an era of public or state surveys.

In mineralogy, Parker Cleaveland of Bowdoin College was active. As early as 1816, he had published his *Elementary Treatise on Mineralogy and Geology*. It was a sizeable book of 668 pages with many crystal drawings and a colored geological map. It was revised in 1822. Cleave-

* Address delivered at the dinner of the Geological Society of America and affiliated societies at Washington, D.C., December 29, 1937.

land planned a third edition, which could not be finished because of ill health. This pioneer text was followed by Charles U. Shepard's *Mineralogy*, which appeared in two parts, in 1832 and 1835. Shepard wrote his book while serving as an assistant to the great Benjamin Silliman at Yale University. These were the only important American books on the subject. Naturally they aroused much interest.

As mineralogy in Europe was much more advanced than in this country, Cleaveland and Shepard had obviously been obliged to draw freely upon the writings of English, French, and German crystallographers, mineralogists, and chemists. Among the European stalwarts who were laying the foundations of crystallography and mineralogy during this period, mention may be made of Mohs at Vienna, Naumann and Breithaupt at Freiberg, C. S. Weiss and Gustav Rose at Berlin, Whewell and Miller at Cambridge, Brewster at Edinburgh, Berzelius at Stockholm and Von Kobell at Munich. The French crystallographers, Rome de L'Isle and Haüy were of an earlier generation. At Yale University, where the *American Journal of Science* had been founded by Silliman in 1818 and was being issued by him, the publications of American and foreign scientists were, of course, being closely followed.

Such, in brief, was the general situation in science, and particularly in mineralogy, in this country, when James Dwight Dana, at the age of seventeen, entered Yale University as a sophomore in 1830. He was able to graduate three years later. During his college course he naturally came under the influence of Silliman, by whom his early interest in minerals and geology was greatly stimulated. In his senior year, Dana received an appointment as instructor of mathematics to Midshipmen of the United States Navy. This took him on a cruise to the Mediterranean. Although he had no access to minerals, he used his leisure hours on the trip working on difficult problems in mathematical crystallography.

In 1835 Dana returned to Yale and began the preparation of his *System of Mineralogy*. It seems almost incredible that a youth of but twenty-two, whose whole experience was limited to that which he had received at Yale and on a Mediterranean cruise, should undertake the writing of so important a text. But Yale was the center of mineralogy at that time, and Silliman's extensive library, which included all the important texts and scientific journals, was at Dana's disposal. Accordingly, he was familiar with the writings of the European leaders already referred to. The book went to press in December 1836, and was published in the spring of 1837. It was a volume of 586 pages with many crystal drawings.

An examination of this remarkable contribution reveals at once that young Dana was fired with an intense ambition to advance mineralogy in this country. Witness the following excerpts from the preface: "The tardy progress of mineralogy in this country, and in England, presents a striking contrast with its rapid advancement in continental Europe. . . . The hope of filling up, in some degree, the existing blank in these departments of American Mineralogical Science, and of contributing to its advancement, by combining the various excellencies from the most valuable works on this Science, has induced the author to offer the following Treatise to the American public." Although Dana frankly admitted that he had drawn heavily upon earlier writers, especially Häuy, Mohs, and Naumann, much original material was included.

This volume, completed at the age of twenty-four, immediately received most favorable comment. Thus the extensive review published in the *American Journal of Science*, late in 1837 includes the following statements, "We see here how little this nation has, until recently, done for the advancement of a science, a knowledge of which is so important to the full development of the resources of the country. This cause of reproach is now, however, fast disappearing. . . . The industry, research and scientific attainment, evinced in the execution of this work, afford satisfactory evidence of the ability of the writer. . . . We believe this to be decidedly among the best treatises upon this subject that have ever been circulated in the United States, and we are of the opinion that even a slight examination of it, will be sufficient to commend it to the favor of every cultivator and lover of Mineralogy."

That the book commended itself to mineralogists is evidenced by the rapid succession of revised editions. The second came in 1844, the third in 1850, the fourth in 1854, the fifth in 1866, and the sixth in 1892, followed by appendixes in 1899, 1909, and 1915. Professor G. F. Brush assisted with the fifth edition. The sixth edition and the first appendix were by his son, Edward S. Dana. Professor W. E. Ford collaborated with the younger Dana in the preparation of the second appendix, and was entirely responsible for the third. More than fifteen hundred pages are included in the sixth edition and the three appendixes. They are packed with facts and information that every serious student of mineralogy must have. Accordingly, Dana's *System* is to be found in scientific laboratories and libraries the world over. It is referred to in mineralogical literature more frequently than any other reference work. It has been well characterized as the mineralogist's bible.

The seventh edition has been in preparation for some time under the direction of Professors W. E. Ford and Charles Palache. Mineralogists

the world over rejoice that the Geological Society of America has made a substantial grant so that the new edition may be speedily completed. They also consider it most appropriate that during this centennial year our foremost mineralogist, who is one of the editors of the new edition, should have served as President of this Society.

This remarkable contribution of one hundred years ago by a young man of but twenty-four has constantly grown in vitality and influence. Today it is used more than ever before. It is a world authority. That this status will be continued well into a second century is assured by the very able leadership being given by Professors Palache and Ford to the preparation of the seventh edition. In this respect I believe that Dana's *System of Mineralogy* is unique among American scientific publications. Accordingly, it is eminently fitting that upon this occasion a brief reference should have been made to what may be termed "A notable centennial in American mineralogy."

KEILHAUTE, A GUIDE MINERAL TO THE STERLING GRANITE GNEISS OF RHODE ISLAND

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INTRODUCTION

During the study of the heavy accessory minerals of a suite of specimens of the Sterling granite gneiss from Exeter, Rhode Island, sphene with abnormally low indices of refraction was found. Upon further examination, this mineral proved to be the variety keilhauite. Samples of the granite were examined from widely separated outcrops, and wherever sphene was found, it proved to be this variety. Crystals of normal sphene were not found in the Sterling granite gneiss. Several specimens of the Milford granite to the north were examined, but no keilhauite was found. The two specimens of Milford granite examined contained a mineral so badly altered to leucoxene that its optics could not be determined. The keilhauite from the Sterling granite gneiss from Exeter was unaltered.

The writer is greatly indebted to Dr. Alonzo Quinn of Brown University for his aid in obtaining the specimens for this work, and to Dr. Esper S. Larsen, Jr., and Dr. Harry Berman for their many helpful suggestions during the course of this study. The writer also desires to thank Mr. W. E. Richmond for the x-ray photographs of keilhauite and sphene which he kindly made.

LOCATION

The specimens studied were all fresh, unweathered samples and were obtained from recent road cuts. A traverse was made along the Ten Rod Road from the village of Exeter in Exeter township, west to the Nooseneck Hill Road, thence south-south-west about a mile to the new Beach Pond Road, and then due west along the Beach Pond Road to the Connecticut boundary (Fig. 1). Six specimens from outcrops spaced at least a mile apart and one specimen from a road cut near the Kent Dam of the Scituate Reservoir, twelve miles north of the eastern part of the traverse, were studied. Samples of the Milford granite and of keilhauite and sphene from the Harvard University collections were examined for comparison. The sphene from Manton, Rhode Island, was furnished by Dr. Alonzo Quinn of Brown University.

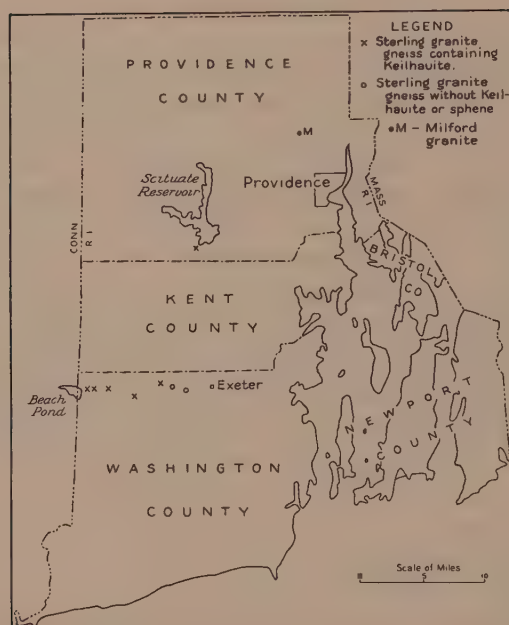


FIG. 1. Index map of Rhode Island, showing location of specimens studied.

METHODS USED

About seventy-five grams of each specimen were crushed to pass an eighty-mesh screen, washed free of dust, and passed through bromoform. The heavy fraction was subdivided with an electromagnet and the keilhauite concentrated in the weakly magnetic fraction.

The optical properties of the keilhauite were determined by immersing the grains in solutions of yellow phosphorus and sulphur in methylene iodide as described by West.¹

CHARACTERISTICS OF KEILHAUITE

Keilhauite was distinguished from normal sphene on the basis of its somewhat larger optic angle and its appreciably lower indices of refraction. The refractive indices vary somewhat, but are generally lower than those of most sphenes. Below is a comparison of the indices of refraction of keilhauite from Rhode Island, Norway, and South Africa with sphene from Rhode Island.

¹ West, C. D., Immersion liquids of high refractive index: *Am. Mineral.*, vol. 21, pp. 245-249, 1936.

	α	β	γ	2V	Sp. Gr.	
Y708	1.855	1.874	1.972		3.50	keilhauite, Exeter, R.I.
Y710	1.870	1.890	1.990			keilhauite, Exeter, R.I.
Y721	1.843	1.870	1.943	35-40°	3.557	keilhauite, Exeter, R.I. (analyzed)
87737	1.889	1.910	2.032			keilhauite, Arendal, Norway
89494	1.882	1.900	2.000	30°		keilhauite, Kahn Mine, S.W. Africa
Manton	1.900	1.918	>2.060	10-15°	3.52	sphene, Manton, R.I.

It should be noted that the indices of refraction for keilhauite as given by Larsen and Berman² and Winchell³ are high, and probably inaccurate, as suggested to the writer by Dr. Larsen. In all cases the dispersion was strong, $r > v$, and the optical character positive.

Several kilograms of the rock containing the keilhauite of lowest refractive indices, Y721, were crushed and about one gram of keilhauite was carefully separated. This keilhauite was analyzed by F. A. Gonyer with the following result:—

	Percentages	mol. ratios
SiO ₂	29.85	.497
TiO ₂	30.65	.384
Al ₂ O ₃	7.32	.072
Fe ₂ O ₃	6.17	.039
FeO	none	
MnO	none	
MgO	none	
CaO	22.37	.399
H ₂ O	0.32	
Y ₂ O ₃ } Ce ₂ O ₃ }	3.58	.013
	100.26	

A comparison of the analysis of keilhauite with analyses of sphene was attempted, but was difficult because of the lack of good sphene analyses. Most of the analyses are over fifty years old and were made before the introduction of more refined methods of chemical analysis, and in many of these but three constituents were determined, SiO₂, TiO₂ and CaO. The writer wishes to point out the need for more accurate chemical analyses of sphene with careful determinations especially for titania, alumina, and ferric iron.

The amount of silica in five keilhauite analyses⁴ examined seems to be about the same as in the Rhode Island keilhauite, while in twelve

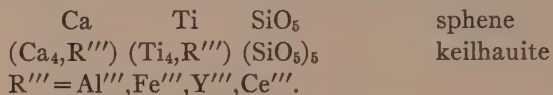
² Larsen, Esper S., and Berman, Harry, *The Microscopic Determination of the Non-opaque Minerals*, U. S. Geol. Survey, Bull. 848, p. 143, 1934.

³ Winchell, N. H., and Winchell, A. N., *Elements of Optical Mineralogy*, Part II, Descriptions of minerals, 3rd ed., John Wiley & Sons, Inc., New York, p. 205, 1933.

⁴ Doelter, C., *Handbuch der Mineralchemie*, III, 1, pp. 59-66, 1918.

sphenes, including the variety grothite, it ranges from 28.26% to 36.79%. Titania varies from 26.67% to 29.01% in the keilhauites, slightly lower than that of Rhode Island, and varies from 30.40% to 41.41% in the sphenes. Alumina, ferric iron, and rare earths— R_2O_3 —range from 1.68% to 11.65% in the sphenes, and from 12.81% to 24.22% in the keilhauites. Lime is generally lower in keilhaute than in sphene, 17.15% to 22.37% in keilhaute and 20.51% to 31.41% in sphene.

X-ray powder patterns for the Rhode Island keilhaute and for sphene from Renfrew, Canada, show identical spacing and intensity. It would appear therefore that keilhaute and sphene have the same fundamental structure. Zachariasen⁵ studied the structure of sphene. In keilhaute and some sphenes R_2O_3 apparently replaces both lime and titania. The following formulas express the compositions closely:



CONCLUSIONS

This study indicates that keilhaute might be used as a guide mineral to distinguish the Sterling granite gneiss from other nearby granite gneisses of similar appearance. Further work may, however, show that the keilhaute is confined to but a portion of the Sterling. For rapid work, but a small quantity of the rock would need to be crushed and the α index alone determined. A great many such immersions could be made in a few hours. Further work might show similar variations in the optical properties of zircon which would make this mineral of value for correlation in some cases.

The writer also wants to emphasize the fact that there appears to be a gradation in chemical composition and optical properties from keilhaute to sphene. A series of chemical analyses of keilhaute and sphene would probably show a fairly simple relation between the index of refraction and the R_2O_3 and TiO_2 content of the mineral.

⁵ Zachariasen, W. H., The crystal structure of titanite: *Zeits. Krist.*, vol. 73, pp. 7-16, 1930.

NOTES AND NEWS

OCCURRENCE OF CRISTOBALITE IN A SEDIMENTARY ROCK

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Some time ago, while investigating microscopically the rocks of Transcaucasia, we came across a very curious occurrence of Upper Tertiary argillaceous sandstone that contains a considerable quantity of cristobalite together with quartz. This specimen of sandstone was found in 1935 near the village of Nomanevi, in Western Georgia, near the contact with an overlying basalt. In general, cristobalite is not rare in sedimentary formations, and it has been listed many times as associated with such typically hydrochemical minerals as opal or montmorillonite.

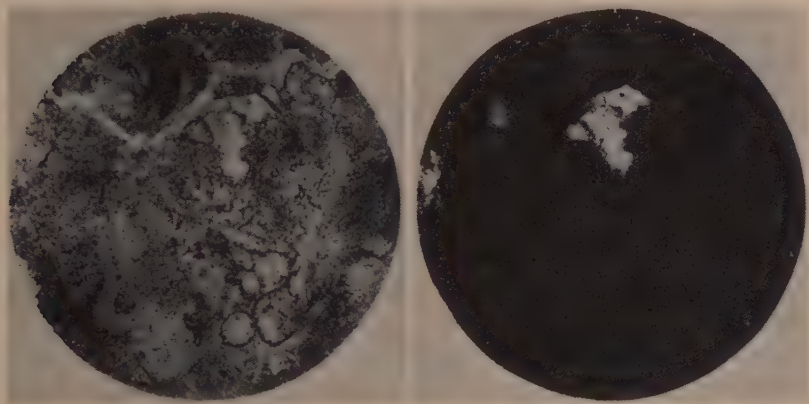


FIG. 1. Photomicrograph of a sandstone with quartz largely replaced by cristobalite. Remnants of quartz above center. $\times 100$.

FIG. 2. Same as Fig. 1. Crossed nicols. $\times 100$.

Therefore, it was not the cristobalite occurrence in the Nomanevi sedimentary rock that astonished us, but the mode of its occurrence in that rock, which indicated its secondary origin by means of a gradual cristobalitization of the primary quartz grains. This cristobalitization with an islet of preserved quartz is well seen in the photomicrographs Figs. 1 and 2.

We have briefly described this sandstone in our publication "Cristobalite in the Rocks of Caucasus and Transcaucasia" (in Russian, *Ac. of the U.S.S.R. Trans., Math. and natur. sc. section, geol. series*, 1936, No. 2-3, pp. 311-312). There we compared the cristobalitic regenera-

tion of quartz in the Nomanevi rock with similar regeneration of this mineral in the manufacture of silica brick, and during its use in a Martins metallurgical furnace. There the cement of the Nomanevi sandstone was described and the chemical analysis of the rock, which we repeat in Table 1, was given.

TABLE 1. CHEMICAL ANALYSIS (BY K. P. SOKOVA) OF THE NOMANEVI SANDSTONE (SAMPLE NO. 295)

Composition	Percentage	Molec. ratios
SiO ₂	60.14	1.002
TiO ₂	0.88	0.011
Al ₂ O ₃	15.55	0.152
Fe ₂ O ₃	5.06	0.032
FeO.....	0.36	0.004
CaO.....	0.81	0.014
MgO.....	1.12	0.028
MnO.....	0.07	0.001
BaO.....	0.02	—
K ₂ O.....	0.78	0.009
Na ₂ O.....	0.27	0.005
H ₂ O+.....	6.90	0.383
H ₂ O-.....	8.02	0.444
Total.	99.98	

An examination of this analysis shows that, in addition to a very moderate percentage of SiO₂ for a sandstone, the Nomanevi rock is rather high in both Al₂O₃ (and Fe₂O₃) and H₂O, and that more than half of the latter is driven off below 110°C. The ratios of Al₂O₃ (and Fe₂O₃): H₂O correspond approximately to a ferric halloysite, in agreement with the microscopic properties of the argillaceous material in the rock, which is isotropic and has an index of refraction of $N=1.549 \pm 0.005$. Larsen and Berman give in their tables¹ $N=1.542$ for halloysite with the formula Al₂O₃·2SiO₂· n H₂O, $N=1.554$ for halloysite with the formula Al₂O₃·2SiO₂·2H₂O. The Nomanevi halloysite has $n > 2$, as in Larsen's first example. Its high refraction (compared with $N=1.542$) is caused probably by the presence of Fe₂O₃, and possibly by other oxides in solid solution or in the molecule of the mineral. The remaining oxides must be in some way distributed in those fine opaque particles which contaminate the argillaceous material. These particles are, in general, so finely dispersed that they give no possibility of an accurate microscopic

¹ Larsen, E. S., and Berman H., *The Microscopic Determination of the Nonopaque Minerals*, 2nd Edition, Washington, 1934, p. 51.

determination. Only in a few places they become large enough to permit a more or less distinct determination as fine plates of translucent hematite with red color.

The special peculiarity of the Nomanevi rock was the formation of cristobalite from quartz. The principal difficulty in explaining this lies in the fact that, according to modern conceptions based on Fenner's² experiments, quartz at relatively low temperatures up to 870° forms only one truly stable crystalline phase of anhydrous silica, which at these low temperatures is unable to undergo either direct tridymitization or cristobalitization. Therefore, for the interpretation of the peculiar Nomanevi paragenesis we have only the three following possibilities.

1. There was no actual direct alteration of quartz into cristobalite, but we have an intermediate regeneration of quartz under the influence of mineralizers with the formation of hydrosilicate gel or opal from which the metastable cristobalite crystallized normally, according to Ostwald's rule.

2. The direct alteration of quartz into cristobalite resulted from the contact effect of basaltic magma at temperatures higher than 870°; there also was a simultaneous dehydration of halloysite; further, on later decrease of temperature, there occurred a new hydration of halloysite.

3. The direct alteration of quartz into cristobalite took place at low temperatures in a medium rich in H₂O in the presence of halloysite.

The first of these possibilities appears to be excluded due to entire absence of any intermediate medium between the relics of quartz in the thin sections and the cristobalitic substance which surrounds them.

The third possibility is reasonable only on the assumption of insufficient data on Fenner's diagram, which on this theory would require additional experimental rechecking.

The second possibility appears to be the most probable of the three, but we have no evidence of its actual realization.

² Fenner, C. N., The stability relations of the silica minerals: *Am. Jour. Sc.*, 4th Ser., vol. 36, pp. 331-384, 1913.

A NOTE ON THE INTERPRETATION OF ETCH FIGURES

EDGAR T. WHERRY, *Philadelphia, Pennsylvania.*

One of the first principles learned by the student of crystallography is that the 32 crystal classes differ primarily in their general form (hkl) or ($hk\bar{l}$), and except in the triclinic system and a few special cases in other systems, the remaining six forms are morphologically identical through two or more classes. In several recent publications on etch figures this principle has, however, been overlooked, leading to some misunderstandings which deserve an attempt at clearing up.

In an interesting paper by Honess and Jones¹ it is shown that the etch figures on several forms of calcite produced by certain solvents exhibit a lower degree of symmetry than that usually ascribed to this mineral, yet the basal pinacoid (0001) in their experiments yielded only figures possessing the full crystallographic symmetry. These authors consider this as in some way connected with the arrangement of atoms in the structure, and recommend more extended study. Their diagram on page 684 shows, however, that the figures in question are not bounded by a general form, but by a rhombohedron ($0h\bar{h}l$), a form which occurs in several classes and accordingly is incapable of revealing merosymmetry at all. Further study of the matter is indeed desirable, but it may well be of practical character, consisting of trying additional etch media until one is found which produces on the base figures bounded by the general form (hkl). Only in this way can it be ascertained whether or not the basal pinacoid of calcite is in fact anomalous with respect to the other forms.

Two suggestions may be made as to the lines along which search for such etch media might be profitable. It has been observed that the symmetry of etch figures may become lessened when the etching liquid is made more concentrated. (According to the principle above discussed, this merely means that the more dilute solutions yield figures bounded by some of the 6 forms other than the general one.) No doubt the critical concentration for the appearance of (hkl) or ($hk\bar{l}$) bounding faces on the figure varies from one form to another, and is higher for the base than for any other form. Its maximum value may conceivably be attained by the use of more soluble etching compounds.

On the other hand, the appearance of modifying faces on crystals is often stimulated by the presence of impurities, both crystalloids and colloids, in the solutions. Perhaps small amounts of accessory substances might lead to the development of complex, and ultimately general, bounding faces on etch figures as well.

¹ *Bull. Geol. Soc. Amer.*, vol. 48, p. 667, 1937.

The contradictory results which have been obtained by workers on the etch figures of sylvite and other halides may well be connected with the principle here under discussion. One worker may have used an etching medium which yields only (111) pits, and since this form is geometrically the same in all five classes of the cubic system, he reports holosymmetry. Another may have chanced upon a medium capable of producing (*hkl*) pits, and finds them asymmetric. I have sought in vain in the controversial papers on the etching phenomena of halides of the past 20 years for a recognition of this elemental principle. Perhaps our textbooks are to blame, in that they do not emphasize the point, and the diagrams of etch figures they give are often misleading in this very respect.

BROMYRITE FROM TOMBSTONE, ARIZONA*

CHARLES ALFRED RASOR, *Tucson, Arizona.*

Bromyrite at Tombstone, Arizona, here described, is believed by the writer to represent the first authenticated occurrence from the United States, though others have mentioned it without publishing a chemical analysis. Search for this mineral has been made, especially in the silver districts of Nevada.

In the study of the mineralogy of the Tombstone district, several specimens of unusually well crystallized dark green "horn silver" had not changed its color since they were first collected by the writer in April 1935. Specimens collected before that date by others had, also, not changed color. Therefore, a carefully separated sample of about 3 grams submitted to the chemistry department of the University of Arizona was analyzed by Mr. R. Carrillo under the supervision of Dr. R. L. Nugent and gave the following composition:

	Per cent	Ratios	
Cl	0.6	.017	.524
Br	38.9	.487	
I	2.6	.020	
Ag	56.7	.526	.526
	<hr/> 98.8		

The analysis shows the mineral to be bromyrite, probably containing, isomorphously, small proportions of iodyrite and cerargyrite.

The silver haloid, mined from the surface to the lowest depths of oxidation, both in the early days and at present, has been called cerargyrite without any mention that bromine was a constituent. In unpublished

* Published by permission of the Director, U. S. Geological Survey, and the Director, Arizona Bureau of Mines and Geology.

notes on the Tombstone district, Dr. F. L. Ransome did mention embolite, $\text{Ag}(\text{Br}, \text{Cl})$, as the principal silver mineral in the ores from the State of Maine mine, which is four or five miles west of the main producing area.

Many specimens of rich silver ore were collected showing bromyrite crystals, such as the cube modified by the octahedron. Other specimens showed bromyrite as large masses of greasy dark green scales associated with hydrous iron oxides, cellular quartz, and cerussite. Some excellent specimens from the rich silver ores of the old Flora Morrison mine and the Empire mine contain bromyrite associated with coiled masses of native wire silver, bright yellow flakes of gold resting on the green bromyrite, and unidentified green ferric tellurites.

The presence of tellurites or tellurates suggests that much of the silver had been derived from the alteration of the silver telluride, hessite. Specimens of hessite were found by the writer in the Flora Morrison ores, but the mineral had been previously described by Genth.¹

The vertical distribution and the relative abundance of the silver haloids at Tombstone is uncertain, but the rare silver bromide is believed to have been the most abundant and to have been concentrated in a fairly definite zone particularly around the 400 foot level. In other mining districts Burgess² has shown that the different haloids, except bromyrite, occupy definite zones in the ore deposits, probably because of the relative concentration of the three halogens, and it is thought that bromyrite occupies a zone between embolite and iodobromite. However, if the three halogens were equally abundant in the mine waters, as suggested by Emmons,³ the bromide and iodide of silver would probably predominate in the silver deposits as suggested at Tombstone by the abundance of bromyrite.

It would be interesting to know if the "horn silver" found at the surface at Tombstone by Ed Schiefflin, and others, was all cerargyrite, or if it was in part or entirely bromyrite. This can not be known unless some one will donate specimens for chemical analysis that were collected in the early days of mining activity.

A feature of the bromyrite at Tombstone is the characteristic odor

¹ Genth, J. A., Hessite from the Westside mine, Arizona: *Am. Phil. Soc.*, vol. **24**, p. 36, 1887.

² Burgess, J. A., The halogen salts of silver and associated minerals at Tonapah, Nevada: *Econ. Geology*, vol. **6**, pp. 13-21, 1911. The halogen salts at Wonder, Nevada: *Econ. Geology*, vol. **12**, pp. 589-593, 1917.

³ Emmons, W. H., The enrichment of ore deposits: *U. S. Geol. Survey, Bull.* **625**, pp. 256-257, 1917.

given off when first exposed to the air. Burgess⁴ has described it as a "drug store or laboratory odor."

The source of so much bromine along with the other halogens is not definitely known, but it may well have been derived from the alkali lakes or playas which are not far distant.

ACKNOWLEDGMENTS

This study of bromyrite represents a portion of a thesis on the mineralogy of the Tombstone mining district, Arizona, which was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Arizona. The writer is indebted to Dr. B. S. Butler for guidance and criticism in the preparation of the manuscript, to Dr. E. D. Wilson, geologist for the Arizona Bureau of Mines, for many helpful suggestions, and to Dr. W. T. Schaller for critical reading.

⁴ Burgess, J. A., *op. cit.*, p. 593, 1917.

PROCEEDINGS OF THE EIGHTEENTH ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT WASHINGTON, D.C.

PAUL F. KERR, *Secretary*

The eighteenth annual meeting of the Society was called to order Wednesday, December 29th, at 1:30 P.M. in the Rose Room of the Hotel Washington, Washington, D.C., President Norman L. Bowen presiding. The customary business of the Society was conducted, including reports by the officers of the Society and committees summarized as follows:

MINUTES OF THE LAST ANNUAL MEETING.

REPORT OF THE SECRETARY.

REPORT OF THE EDITOR.

REPORT OF THE TREASURER.

MEMORIALS:

Brief oral tributes were presented by Dean Edward H. Kraus of the University of Michigan for Reinhard Brauns and A. H. Phillips, late Fellows of the Society.

COMMITTEES:

REPORT OF THE AUDITING COMMITTEE

The business meeting was adjourned at 2:00 P.M., and the president, Norman L. Bowen, called for the presentation of papers. The report of the election of officers and fellows for 1938, the reports of the Secretary, Editor, and Treasurer, and the reports of the committees are given in the following pages.

ELECTION OF OFFICERS AND FELLOWS FOR 1938

The Secretary announced that 282 ballots had been cast for the officers as nominated by the Council. The officers for 1938 are as follows:

President: Ellis Thomson, University of Toronto, Toronto, Canada.

Vice-President: Kenneth K. Landes, University of Kansas, Lawrence, Kansas.

Secretary: Paul F. Kerr, Columbia University, New York, N.Y.

Treasurer: Waldemar T. Schaller, U. S. Geological Survey, Washington, D.C.

Editor: Walter F. Hunt, University of Michigan, Ann Arbor, Michigan.

Councilor, 1938-1941: R. C. Emmons, University of Wisconsin, Madison, Wisconsin.

The Secretary announced that according to the provisions of the Constitution, the following had been elected to Fellowship in the Mineralogical Society of America:

Henry R. Aldrich, 419 West 117 St., New York, N.Y.

Donald M. Fraser, Lehigh University, Bethlehem, Pa.

William T. Gordon, Kings College, Strand, London W.C. 2, England.

Maharajapuram Sitaram Krishnan, 27 Chowringhee, Calcutta, India.

Donald H. McLaughlin, Harvard University, Cambridge, Mass.

James A. Noble, 7 North Blue St., Lead, South Dakota.

Frederick H. Pough, American Museum of Natural History, New York, N.Y.

Vojtech Rosicky, University Masaryks Brno, Kounicora 59, Czechoslovakia.

Quentin D. Singewald, University of Rochester, Rochester, N.Y.

Benjamin M. Shaub, Smith College, Northampton, Mass.

Lloyd W. Staples, 223 Cowper St., Palo Alto, California.

Edward H. Watson, Bryn Mawr College, Bryn Mawr, Pennsylvania.

REPORT OF THE SECRETARY FOR 1937

To the Council, Fellows and Members of the Mineralogical Society of America:

MEMBERSHIP STATISTICS

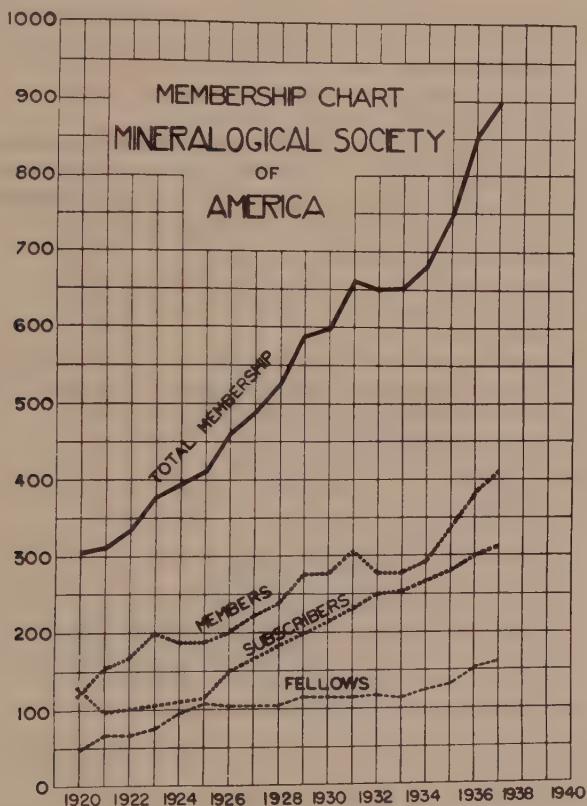
	1936	1937
Correspondents	4	5
Fellows	154	160
Members	387	414
Subscribers	305	317
	<hr/>	<hr/>
	850	896

GAIN AND LOSS FOR 1937

	<i>Gain</i>	<i>Loss</i>
Correspondents	2	1
Fellows	12	6
Members	91	64
Subscribers	45	33
	<hr/>	<hr/>
	150	104

During 1937 the Mineralogical Society of America has made a net gain in membership of 46, or approximately $5\frac{1}{2}\%$ on the basis of the 1936 total. There has been a gain in both members and subscribers for the past year, although not as great as the gain in 1936. As in the previous year, the greater gain has been in members. It is interesting to note that of the 576 fellows and members, 85 are from foreign countries and 30 from Canada. This is approximately one-fifth of the total.

Over 900 copies of *The American Mineralogist* are distributed each month, more than 150 going to Europe, Asia and Africa. Libraries and institutions in 39 states subscribe to the *Journal of the Society*.



The membership chart, which was published with the Secretary's report for 1936, has been brought up to date for the period ending December 31, 1937.

Respectfully submitted,

PAUL F. KERR, *Secretary*

REPORT OF THE EDITOR FOR 1937

To the Council, Fellows and Members of the Mineralogical Society of America:

From the standpoint of published material the year 1937 will long be remembered as one of unusual accomplishments. It should be recalled that under normal conditions, based on the experience of recent years, the publications of the Journal might be expected to aggregate about 800 pages annually, so that an increase in a single year of about 400 pages beyond this figure is a very gratifying achievement. The issuance this year of a volume of approximately 1200 pages was due mainly to the greatly enlarged May number dedicated to Professor Charles Palache. This number alone carried 35 articles and totaled 436 pages, thus increasing the pagination for the year to a new high level. To the numerous former students and friends of Professor Palache who in one way or another made this number possible, we are extremely grateful. Likewise the Editor wishes to take this occasion to express his deep appreciation to Dr. Peacock and his associates for looking after the numerous details connected with the printing of this special issue.

A critical review of volume 22 shows that it contained 96 leading articles which occupied 88.7% of the total space of the Journal. In addition to these major contributions 24 shorter articles were accepted, making a total for the year of 120 published manuscripts. These contributions were received from 123 contributors representing 54 different universities, research bureaus and technical laboratories.

It is of interest in this connection to record that ten papers originated outside of the States: 5 were received from England, 2 from Norway, and one each from Canada, Switzerland and Soviet Russia,

Each year the number of mineral species is increased by the discovery of naturally occurring inorganic compounds not previously recorded. *The American Mineralogist* for 1937 carried detailed descriptions of six of these new minerals—roweite, dakeite, illite lopezite, woodhouseite and hilgardite.

To bring before our readers reviews of new books that have appeared in the fields of mineralogy and petrography is one of the important functions of the Journal, and during the current year 13 such reviews have been prepared and printed.

It is difficult at times to classify accurately the specific fields represented by some of the papers submitted, due to their over-lapping character, but an analysis of the main articles has been attempted and revealed the fact that descriptive mineralogy, chemical mineralogy, structural crystallography and geometrical crystallography are each represented by at least 14 papers, Petrography followed these closely with 12 contributions.

The council of the Geological Society of America, at a meeting held last October, voted to continue during 1938 the grant of \$1,500 which is to be used to defray in part the cost of publishing the Journal.

The accompanying table of contents summarizes in detail the distribution of subject matter in volume 22.

DISTRIBUTION OF SUBJECT MATTER IN VOLUME 22

<i>Subjects</i>	<i>Articles</i>	<i>Pages</i>	<i>Per Cent of Total</i>
Leading articles			
Descriptive mineralogy	17		
Chemical mineralogy	14		
Mineralography	5		
Structural crystallography	16		
Geometrical crystallography	15		
Petrography	12		
Optical mineralogy	5		
Memorials, miscellaneous	12		
	96*	1056	88.7
Short articles	24	55½	11.3
Proceedings of societies	25	40	
Notes and news	14	24	
Abstracts of new mineral names	21	6½	
Book reviews	13	8	
<i>Total of text</i>	193	1190	100.0
Illustrations	323		
Index, covers, advertisements		124	
Total		1314	

*(Average length of leading articles, 11 printed pages.)

Respectfully submitted,

WALTER F. HUNT, *Editor*

REPORT OF THE TREASURER FOR 1937

To the Council of the Mineralogical Society of America:

Your Treasurer submits herewith his annual report for the year beginning December 1, 1936, and ending November 30, 1937.

RECEIPTS

Cash on hand December 1, 1936.....	\$ 2,886.32
Dues and subscriptions.....	2,522.60
Advertisements.....	401.10
Sale of back numbers.....	493.21
Authors' charges on separates.....	870.87
Interest on endowment.....	2,349.50
Sale of 20-volume index.....	51.00
Geological Society of America grant for 1937.....	1,500.00
Contribution to Palache (May) issue.....	1,813.97
Transfer from Roebling Medal Fund.....	125.00

\$13,013.57

DISBURSEMENTS

Printing and distribution of the Journal (12 issues)	\$ 7,152.22	
Printing and distribution of separates	1,138.34	
To the Editor, Secretary, and Treasurer	970.00	
Postage	142.92	
Printing	195.43	
Stationery	16.78	
Clerical help	255.94	
Committee expenses	3.40	
Safety deposit box	8.25	
Bank collecting charges	2.91	
Telegrams	6.16	
Refund on dues	8.16	
Roebbling Medal Fund	100.00	
Partial payment, Roebbling Medal	125.00	
Advertising commission	11.26	
Incorporation cost	3.40	
	<hr/>	
	\$10,140.17	
Cash balance November 30, 1937	2,873.40	
	<hr/>	
		\$13,013.57

The endowment funds of the Society as of November 30, 1937, consist of the following securities and cash:

4 \$100 bonds, Great Northern Railway Co., Genl. mtg., 5½%, due January 1, 1952	\$ 400.00
1 \$500 bond, Union Pacific Railroad Co., First lien and ref. mtg., 4%, due June 1, 2008	500.00
1 \$1,000 bond, The Denver Gas and Electric Light Co., First and ref. mtg., 5%, due May 1, 1951	1,000.00
45 \$1,000 bonds, City and County of Honolulu, Territory of Hawaii, Water Works, 5%, due April 15, 1954	45,000.00
37-514/1000 shares, Preferred Stock, Trenton Mortgage Service Co., Trenton, N.J.	3,751.40
Cash	248.60
	<hr/>
	\$50,900.00

The Trenton Mortgage and Title Guaranty Company of Trenton, N.J., was reorganized into the Trenton Mortgage Service Company, and the Certificates of the former company, previously held, exchanged for preferred stock in the latter company.

In addition, there is \$300.00 in U. S. Postal Savings bonds, and \$75.00 in cash, laid aside for the Roebbling Medal Fund.

Respectfully submitted,

WALDEMAR T. SCHALLER, *Treasurer*

DANA FUND

Statement of the Special Dana Fund of the Mineralogical Society of America, initiated by Prof. E. S. Dana, and since his death cared for by the Treasurer. Disbursement made to the daughter of Prof. F. Berwerth, in Vienna, Austria.

RECEIPTS

Available balance November 30, 1936.....	\$1,261.95	
Interest.....	26.22	
Contribution.....	10.00	
		<hr/>
		\$1,298.17

DISBURSEMENTS

Disbursed.....	\$ 180.00	
Available balance November 30, 1937.....	1,118.17	
		<hr/>
		\$1,298.17

Respectfully submitted,
WALDEMAR T. SCHALLER, *Treasurer*

REPORT OF THE AUDITING COMMITTEE

To the President of the Mineralogical Society of America:

The Auditing Committee has examined and verified the accounts and report of the Treasurer for the fiscal year ending November 30, 1937. The securities listed in the Treasurer's report are in the safety deposit box at the American Security and Trust Company of Washington, D.C. All future coupons on the coupon bonds are attached. In addition there is in the box \$300.00 in U. S. Postal Savings Bonds and \$75.00 in cash laid aside for the Roebling Medal Fund. There is also in the box \$248.60 in cash, representing payments on the principal of the certificates of the Trenton Mortgage and Title Guaranty Company.

Respectfully submitted,
WILLIAM F. FOSHAG
EUGENE CALLAGHAN
WILBUR S. BURBANK

MINERALOGICAL SOCIETY OF AMERICA ANNUAL LUNCHEON

On Wednesday, December 29th, members and friends of the Mineralogical Society of America assembled in the Sun Parlor of the Hotel Washington for the annual luncheon of the Society. After a most enjoyable luncheon, President Norman L. Bowen arose to announce the presentation of the first Roebling Medal.* Dean Edward H. Kraus of the University of Michigan gave the presentation address, in which he outlined the history and purpose of the Roebling Medal, and the more important events in the life of Professor Charles Palache, the first recipient. Professor Palache received the medal, amid the applause of all gathered at the luncheon. In thanking the Society he spoke of his acquaintance with Colonel Washington A. Roebling, and related a number of his experiences as a mineralogist.

* Presentation address and acceptance, *Am. Mineral.*, vol. 23, pp. 54-61, 1938.

PRESIDENTIAL ADDRESS AND PRESENTATION OF PAPERS

MENTE ET MALLEO ATQUE CATINO

BY NORMAN L. BOWEN

A consideration of the three-fold character of investigation in mineral science and a plea for better coordination of effort in these activities. (Complete address in this issue.)

VOLCANOES OF THE MEDICINE LAKE HIGHLAND, CALIFORNIA*

BY CHARLES A. ANDERSON

The Medicine Lake Highland in northeastern California rises above the western margin of the Modoc lava plateau. The highland is a broad Pleistocene shield volcano of platy andesite, 20 miles in diameter, perched upon Pliocene plateau basalt (Warner basalt). Following the formation of the shield, a caldera, 4 to 6 miles across, formed by collapse. Renewed activity took place along the margins of the caldera, more viscous lava poured into it until the marginal volcanoes rose above the caldera walls and discharged lava down the outer slopes of the shield. An elliptical rampart of later volcanoes now marks the location of the original caldera walls. Recent volcanic activity is indicated by scattered parasitic basaltic cinder cones and the outpouring of basaltic lava from the outer flanks of the highland. The well-known Modoc lava beds include the northern cover of Recent basalt. Recent dacite and rhyolite flows have been erupted from the central portion of the highland; the rhyolitic flows were preceded by explosive eruptions which have showered the region with pumiceous ejecta. The last of these eruptions probably took place not more than 500 years ago.

* Presented under the auspices of the Geological Society of America.

FLUORITE DEPOSITS IN WESTMORELAND,
NEW HAMPSHIRE*

BY H. M. BANNERMAN AND R. E. STOIBER

The fluorite deposits in Westmoreland, New Hampshire, occur as fissure fillings in a series of tension fractures in granite gneiss. The veins being worked are from three to five feet in width, and some of them have been traced laterally five to six hundred feet. They dip approximately 70 degrees while the foliation of the gneiss in which they lie is generally quite flat. The veins are banded, crustified, and replete with open cavities. The fluorite is accompanied mainly by quartz, but considerable quantities of barite, calcite, dolomite, kaolin and sericite are present, and streaks of such sulphides as chalcopyrite, pyrite, sphalerite, and a little galena appear throughout the deposits, together with some finely crystallized malachite and smithsonite. The veins have suffered no appreciable deformation since their deposition. Data at hand suggest that they are of post-Paleozoic age, possibly Triassic.

* Presented under the auspices of the Society of Economic Geologists.

SURFACE REFLECTION AREAS IN WEISSENBERG PHOTOGRAPHS

BY M. J. BUEGER

A distinction is made between transmitted and surface x-ray reflections. The distribution of these two kinds of reflections on Weissenberg photographs is systematically derived for any crystal habit, for zero- and n -layer photographs, and for both normal beam and equi-inclination technique. Surface reflection areas have two important applications: (1) They are of aid in allowing for absorption in Weissenberg photographs. If the distribution

of faces on the crystal is known, then the Weissenberg projection can be blocked out into contribution areas. (2) They provide an explanation for the distribution of background in Weissenberg photographs. Intense background patterns can be purposely developed under appropriate conditions and they are characteristic of the crystal form development. It is suggested that background patterns may be of aid in the surface goniometry of crystals having faces too small or too imperfectly developed for optical goniometric investigation.

**SILICIFICATION TYPES ALONG THE HANGING
WALL OF THE LONDON FAULT,
MOSQUITO RANGE, COLORADO***

BY ROBERT D. BUTLER†

Dolomitic formations of Devonian and Mississippian age crop out on the east or hanging-wall side of the London fault south of the Alma district. The dolomites contain replacement ore bodies of barite-carbonate-pyrite-sphalerite-galena-tennantite, some of which are associated with vein quartz. The deposits occur within a rudely semicircular area truncated at the west by the London fault. A period of silicification of the dolomites preceded the formation of the ore minerals. Two types of replacement silica have been observed: (1) idiomorphic, in which the silica initially took the form of euhedral quartz crystals which became cemented by additional silica into an aggregate resembling a sandy limestone; (2) allotriomorphic, in which the structure ranges from a felted to a granular aggregate. A lateral zoning pattern of the ores has been recognized by utilizing serial variations of mineralogic and textural features, but the group of deposits as a whole are classed as "cooler" mesothermal. The silicification textures show areal variations which occupy positions in harmony with the zonal concept. Distribution of ore is not related to amount of silicification, but valuable ore bodies have been found only within a small area where certain silicified facies are present. The early epigenetic materials, silica, as well as the late copper, lead, and silver minerals, are areally related to the position of the London fault and by their variations indicate the locus of thermal and solution supply.

* Published by permission of the Director of the Geological Survey, United States Department of Interior.

† Presented under the auspices of the Society of Economic Geologists.

‡ Introduced by W. H. Newhouse.

**MINERAL DEPOSITS OF THE NORTHEASTERN PART OF
THE HUMBOLDT RANGE, NEVADA**

BY EUGENE N. CAMERON

The principal mineral deposits of the northeastern Humboldt Range are found in folded and faulted acid volcanics, overlying Triassic limestones, and Jura-Cretaceous (?) granite porphyry. The deposits are closely associated with major fault zones which trend roughly parallel to the folds. Among the exploited types, two are important: silver-bearing veins and stockworks, and quartz-stibnite veins.

Hypogene sulphides of the silver-bearing veins and stockworks include pyrite, sphalerite, freibergite, silver-bearing galena, and jamesonite, with minor amounts of arsenopyrite, stibnite, chalcopyrite, bournonite, and pyrargyrite. The principal gangue mineral is quartz. Calcite, barite, albite, apatite, scheelite, and epidote occur in places in the veins. Covellite, sooty argentite, and native silver appear to be supergene. The commercial value of the silver deposits is believed to be due to supergene enrichment.

Quartz-stibnite veins in limestone and rhyolite have been worked at several localities. The veins are of the replacement-fissure type and consist of stibnite replacing and filling fractures in massive quartz. Oxidation of a vein in Jackson Canyon yielded workable bodies of intermingled stibiconite and quartz.

Wall rocks of the deposits have been altered by silicification and sericitization, accompanied locally by development of pyrite, arsenopyrite, talc, chlorite, calcite, dolomite, albite, and apatite.

Structural features indicate a close relationship between mineralization and the Jura-Cretaceous (?) deformation which produced the major fault zones. The variety of forms exhibited by the deposits is believed to reflect the structural behavior of different kinds of wall rocks during deformation.

REGIONAL GRANITIZATION AND METAMORPHISM IN NEW ENGLAND*

BY L. W. CURRIER

Origin of granites at Chelmsford-Westford, Massachusetts, and Milford, New Hampshire, is attributed to general intensive granitization of schists by dominantly hydromagmatic processes. Simple injection gneisses are negligible. Metasomatism has developed alkalic feldspars, quartz, and muscovite in definite paragenetic relations, displacing original bases (magnesium, iron, calcium, titanium). The probability is suggested that, driven into upper zones, these bases formed hornblende, garnet, biotite, epidote, and chlorite schists of common regional aspects. Petrographic and field studies of metamorphic rocks in east-central Vermont and adjacent areas to the east and southeast lead to the hypothesis that this process is a fundamental cause of the regional metamorphism. A broad zonal arrangement of granitic and metamorphic rocks is indicated, as follows: (1) a coastal belt of coarse intrusive granite stocks (Maine coast, Rockport, and Quincy, Massachusetts, et al.); (2) a broad belt to the west and northwest composed largely of replacement granites (Chelmsford, Milford); (3) another belt farther to the west and northwest, of dominantly pegmatitic aspects with highly mineralized schists, that contains commercial deposits of mica, garnet, feldspar, and fluorspar; and (4) still farther west and northwest, in western New Hampshire and eastern Vermont a belt of schists showing incipient granitization.

This hypothesis bespeaks a general batholithic invasion of eastern New England. The deeper, dominantly intrusive zone is exposed along the coast, but underlies the entire province east of the Green Mountains, though at progressively greater depths toward the west. The overlying zones of granitization and metamorphism are thus exposed in successive belts as outlined.

* In part Geological Society project 49-33, and in part Geological Survey project on study of New England commercial granites.

† Presented under the auspices of the Geological Society of America.

THE SIGNIFICANCE OF CRYSTAL HABIT

BY J. D. H. DONNAY

Crystal habit depends on two kinds of factors: external (conditions of crystallization, presence of foreign ions, etc.) and internal (symmetry of the motif, structure, etc.). External factors may, for individual crystals, modify the normal habit imposed by internal factors for the species as a whole. A statistical survey of isolated habits usually leads to the recognition of the normal habit.

A study of crystal habit implies consideration of the following features: (1) presence or absence of forms (combinations); (2) relative importance (size, frequency, persistence) of forms; (3) relative importance of zones; (4) rules of zonal development (extinction criteria); (5) relative size of the various faces of any one form (malformation).

All these features but one (malformation) are satisfactorily explained by the influence

of the space-group symmetry: (1) The habit may be predicted if the space-group (or even the diffraction symbol) is known. (2) The "morphological aspect" (or the diffraction symbol) and hence the space-group or possible space-groups may be predicted from the dominant habit features.

One reservation must be made. In many simple ionic structures, chemically different ions may act alike on the morphological development; in such cases, the crystal habit is the expression of the symmetry of ionic positions, regardless of their nature.

STEREOSCOPIC CRYSTAL DRAWING

BY D. JEROME FISHER

Various projections are in use to facilitate the interpretation of crystal solids in terms of the measured angles between their faces or other significant planes, and their edges or analogous directions. The objective of crystal drawing is to furnish a strongly suggestive picture of a plane-faced solid. Of necessity angles will thus be distorted; the essential thing is that they appear to be correct. Various methods of attaining this end to greater or less degree are available; some choice should be made which combines to a maximum extent ease of construction with excellence of result. Stereoscopic pairs drawn in parallel perspective from a gnomonic base are easily prepared and are quite effective, mainly because the depth element in the projection of crystals need never be very large. Anaglyphs are more valuable because of their remarkable plastic properties. They are easily projected on a screen, but require special colored inks when drawn on paper.

U-STAGE AXIAL ANGLE APPARATUS

BY D. JEROME FISHER

This apparatus replaces the inner plate of the regular universal stage. In addition is needed a special condensing lens which substitutes for the whole microscope substage. The new plate supports a small rotatable lower segment, the upper part of which is faced with polaroid. The inverted thin section is clamped to this plate by a ring into which may be placed either a rotatable upper segment or plate fitted with polaroid. Provision is made for synchronous rotation of the two polaroids. This apparatus permits the direct measurement of both $2V$ and $2E$ for not too-small crystals, though abnormally thick sections are needed for minerals of low birefringence. The apparatus should be of value in determining minerals by the V - E - $Beta$ relationship, in obtaining the value of $Beta$ for high-index biaxial minerals, in petrofabric analysis of reasonably coarse-grained rocks not only in terms of the c -axis direction of quartz but of both optic axes in feldspars, and it offers a very simple and convincing demonstration of classroom value that the interference figure is perhaps better regarded as a direction image.

SODIUM BICARBONATE FROM SEARLES LAKE, CALIFORNIA

BY W. F. FOSHAG

Sodium bicarbonate has been encountered in large amounts in one of the deep wells drilled by the American Potash and Chemical Corporation in Searles Lake. It occurs with abundant gaylussite as pockets or thin beds at depths from 120' to the lowest portion of the well at 285'. The common form of occurrence is as an open reticulated mesh of twinned monoclinic crystals. $\alpha=1.375$, $\beta=1.505$, $\gamma=1.582$. Na_2O 36.74, CO_2 51.15, H_2O 10.76, R_2O_3 0.16, CaO 0.20, insol. 0.82. Sum 99.83. Samples of "nahcolite" from near Naples, consist of burkeite and a compound $\text{NaCO}_3 \cdot 3\text{NaHCO}_3$, hitherto unreported as a mineral and could account for the "nahcolite."

ORIENTED INCLUSIONS OF BROOKITE, ZIRCON, AND GARNET IN MUSCOVITE

BY CLIFFORD FRONDEL

Inclusions of brookite, zircon and garnet in muscovite were described with respect to their orientation to the mica. The method of investigation comprised: (1) the measurement of the crystallographic position of each crystal relative to the muscovite, (2) the plotting of the positions thus determined against frequency of occurrence, and (3) identification of positions of preferred orientation by statistical analysis of the frequency plots.

MAKING STRUCTURE MODELS

BY SAMUEL G. GORDON

Holes approximately the size of colored beads (on the scale of 1 cm. = 1 Å) representing atoms are punched in sheets of cellulose acetate (plastocele). The beads are cemented into the holes. The beaded sheets are assembled and placed in a crystal model made of thin glass plates taped at the edges. This mold is filled with partially polymerized "lucite." When hard, the glass mold is removed. The result is a clear glass-like crystal model enclosing beads showing the atomic structure.

THE NEW MINERAL HALL OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA

BY SAMUEL G. GORDON

The mineral collections are now exhibited in newly designed *frameless* glass cases, lined with black velveteen, with concealed lighting (outside of the cases). Large specimens in wall cases are on individual glass shelves supported by concealed brackets. An effort has been made to set each specimen to the best advantage, many being upon glass stands. Labels are of cellulose acetate, printed with aluminum ink from type. Educational exhibits (What is Geology? What is a Mineral? What is a Crystal? etc.) are at the entrance. There is a crystal collection, and an index, with cross references, to the minerals in the cases. The new Fluorescence Exhibit will be automatically set in operation by visitors passing photoelectric cells.

TWINNING IN GLAUBERITE

BY A. C. HAWKINS

Casts in soft solder have been made from cavities in the red Brunswick shales of Triassic age occurring at Milltown in Somerset County, New Jersey. The crystal forms are those of glauberite and in size and perfection they excel modern occurrences of the mineral. Twinning appears to be common, as interpenetration twins; some twinning is similar to the closely related species thenardite, but there appear to be other twinning laws involved. Full elucidation of the problem will require much careful study. (Twinning has never been reported on glauberite.)

CONCERNING THE CRYSTAL STRUCTURE OF THE CLAY MINERALS, DICKITE AND HALLOYSITE

BY STERLING B. HENDRICKS

Dickite, $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$, is shown to have a somewhat random type of structure based upon the space group C_4 -Cc. The structure suggested by J. W. Gruner (Zeits. Krist., vol. 83, p. 394 (1932)) is possibly correct save for this detail. Halloysite, $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 4\text{H}_2\text{O}$, readily dehydrates to metahalloysite, $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$, as was observed by M. Mehmel

(Zeits. Krist., vol. 90, p. 35 (1935)). However it is shown that the hydrated mineral has $(\text{OH})_4\text{Al}_2\text{Si}_2\text{O}_5$ and $2\text{H}_2\text{O}$ layers rather than separate $\text{Al}_2(\text{OH})_6$ and $\text{Si}_2\text{O}_5(\text{OH})_2$ layers as suggested by Mehmel.

ORTHOPYROXENES OF THE BUSHVELD TYPE

BY H. H. HESS AND A. H. PHILLIPS

Orthopyroxenes of the Bushveld Complex and many similar plutonic intrusions have in many cases been described as monoclinic because of small extinction angles observed. This pyroxene, however, when oriented on a universal stage so that it is parallel to (100) or (010) shows parallel extinction, though in other positions the extinction may appear inclined.

A characteristic feature of this pyroxene is the occurrence of very fine parallel striations on many grains when observed under crossed nicols. These striations are extremely thin lamellae of another mineral of approximately the same mean index as the orthopyroxene but of higher birefringence. They are parallel to (010). Furthermore they extinguish at an angle near 35° on either side of the (010) plane of the orthopyroxene when a section of the latter is viewed parallel to its (100) plane. It seems fairly certain that these lamellae are a diopsidic clinopyroxene. They are so oriented with respect to the orthopyroxene that they have their c axes in common, but the b axis of the clinopyroxene coincides with the a axis of the orthopyroxene.

Chemical analyses of these orthopyroxenes, show about 10% diopsidic molecules and a rough estimate of the total volume of the lamellae is also about 10% of the whole pyroxene. This type of orthopyroxene is very common in plutonic rocks but never occurs, so far as the writer is aware, in volcanic rocks, though orthopyroxenes of volcanic rocks show the same proportion of diopsidic molecules. It is, therefore, suggested that the lamellae represent an ex-solution phenomenon which takes place with slow cooling but is prevented by rapid cooling.

The lamellae explain a part of the observed extinction angles as a result of the composite effect of the lamellae and orthopyroxene host when viewed in certain orientations. The remainder of the observed extinction angles is simply due to the orientation of the mineral. Any orthorhombic crystal with prismatic cleavage probably will give extinction angles in certain orientations.

EXPERIMENTS BEARING ON THE RELATION OF PYRRHOTITE TO OTHER SULPHIDES*

BY R. L. HEWITT AND G. M. SCHWARTZ

The problem of the existence of solid solutions between pyrrhotite and pentlandite, chalcopyrite, galena, and sphalerite was investigated by the heat treatment of suitable ores. Pentlandite was put into solid solution in pyrrhotite above 425 degrees C. and upon slow cooling from 800 degrees C. it unmixed. The unmixed pentlandite oriented itself around pyrrhotite grain boundaries and under high magnifications was observed to contain oriented laths of a mineral tentatively called pyrrhotite. The formation of these laths may be caused by the unmixing of a solid solution of pyrrhotite in pentlandite or by the breakdown of pentlandite expelling pyrrhotite.

Pyrrhotite and chalcopyrite form two solid solutions. Pyrrhotite will dissolve in chalcopyrite above 300 degrees C. The two minerals then react to form chalcopyrite which makes a very fine intergrowth with chalcopyrite in an aureole about pyrrhotite masses in the samples treated. Above 600 degrees C. chalcopyrite will dissolve in pyrrhotite and upon unmixing forms oriented laths in the pyrrhotite.

The eutectic intergrowth formed by pyrrhotite and galena has a composition of approximately 71 per cent galena and 29 per cent pyrrhotite by weight. The eutectic temperature

lies between 765 and 775 degrees C. The variation between these figures and those for the artificial PbS-FeS system may be caused by impurities.

Crystallographic intergrowths between pyrrhotite and sphalerite were never produced although such intergrowths have been described and observed in many ores and it is assumed that hydrothermal conditions lower the temperature of formation for such intergrowths considerably below that required in a dry melt.

Small crystals of pyrrhotite, chalcopyrite, and galena were formed and the evidence indicates that they were produced by volatilization and subsequent deposition.

* Presented under the auspices of the Society of Economic Geologists.

STRUCTURE OF THE CALUMET STOCK, COLORADO

BY ARTHUR L. HOWLAND

The Calumet stock, of granodioritic composition, lies at the southern end of the Mosquito Range, about 8 miles northeast of the town of Salida. Its outcrop is about 12 miles in a north-south direction and has a maximum width of slightly over 5 miles, but the outcrop of the southern end is separated from the outcrop of the main mass by overlying Tertiary volcanics. The long axis of the intrusion coincides with a synclinal axis in the Paleozoic rocks. A study of the well-developed platy structure in the intrusive indicates that it has spread out sill-like into the Paleozoic beds, the platy structure being parallel to the steeply or gently dipping sediments on either side.

ADAPTATION OF AN ELECTRICAL COUNTER TO REPLACE THE INTEGRATING MICROSCOPE STAGE

BY CORNELIUS S. HURLBUT, JR.

This electrical tabulator, consisting of a series of counters, has several advantages over the old type integrating stage. The microscope is unencumbered except by a small mechanical stage to which the counter is connected by a flexible cable. The thin section lies directly on the microscope stage, enabling one to take interference figures. As many traverses as one wishes may be made across a thin section and the totals carried by the counters. A counter recording the total distance of traverse makes unnecessary the addition of the individual totals in calculating percentages.

THE MINERALS SEEN ON THE NORTHERN EXCURSION OF THE 17TH INTERNATIONAL GEOLOGICAL CONGRESS

BY CORNELIUS S. HURLBUT, JR.

The "Northern Excursion" went north from Leningrad across Karelia and into the Kola Peninsula. In Karelia only two localities of mineralogical interest were visited, at Shunga and Chupa.

In the Kola Peninsula several interesting mineral localities were visited, most of which were associated with the alkaline rocks of that region. Of most interest were the many minerals and unusual associations found in the Khibine pluton. Here is found the apatite-nephelinite association that is mined by the million tons; also several rare minerals are found there in sufficient quantity to warrant mining.

RELATION BETWEEN PERIOD OF INTRUSION AND PRO- DUCTION OF FOLIATION IN A GRANITIC INTRUSIVE NEAR HANOVER, NEW HAMPSHIRE

BY EDWARD PECK KAISER

The granitic intrusive is largely gneissic, and is wrapped by schist bands. The intrusive boundary is not sharp, but rather consists of a zone of rocks intermediate in both texture and composition between the granitic gneisses and the schists.

Petrographic and field relations indicate that both foliation and linear alignment were produced after complete solidification of the intrusive. Petrofabric diagrams show a typical *b*-girdle with point maxima, indicating that the *b*-axis (linear direction in the rock) was an axis of rotation during deformation. Movement then was at right angles to the linear direction, rather than parallel to it.

Linear alignment, therefore, is not here a flow structure, but a tectonic structure. It may have followed flow structure in part, but some discrepancies are noted.

TUNGSTEN MINERALIZATION AT OREANA, NEVADA

BY PAUL F. KERR

The tungsten deposit at Oreana, Nevada, exhibits a number of characteristics not found in other commercial tungsten deposits in the United States. Beryl, oligoclase, albite, fluorite, phlogopite and quartz are prominently associated with scheelite in the ore. Garnet and epidote ordinarily so common in the contact metamorphic deposits of the western United States are virtually absent. Neither is the mineralization of the quartz-vein type which yields tungsten in a number of western localities. The scheelite mineralization at Oreana is considered pegmatitic, a type of occurrence unique among tungsten localities in the region.

Two forms of deposition have been observed. (1) Scheelite occurs in almost vertical pegmatite dikes cutting metadiorite. The dikes may be composed almost entirely of scheelite, of feldspar, of fluorite or of quartz. Scheelite in these dikes is associated chiefly with sodic plagioclase, phlogopite, and beryl. (2) Scheelite also occurs in lens-like masses along a contact between limestone and metadiorite, associated with sodic plagioclase and phlogopite. The contact plane is undulating but inclined at about 30 degrees, the metadiorite intrusive occurring above the contact plane, the limestone below.

Zones of silicification and alteration lead downward from the limestone-metadiorite contact within the limestone. Traces of scheelite have been found in these zones but no ore. It is believed, however, that these alteration zones in the limestone represent contributing channels leading to ore deposition above.

THE OSSEO, CANADA, METEORITE

BY JOHN PUTNAM MARBLE

This kamacitic iron, a very coarse octahedrite, was found in the Temiskaming District, Ontario, Canada, about 1934. It carries few troilite nodules, and schreibersite is rare. The Newmann lines are bent in places, which may indicate distortion in flight. An etched, polished section, and an analysis of a typical portion have been made.

A STRUCTURAL INVESTIGATION OF THE ISOMORPHISM OF THE APATITE GROUP

BY DUNCAN MC CONNELL

One or more specimens of fluor-apatite, francolite (grodnolite and staffelite), dahllite (including podolite), dehrnite, lewistonite (including kurskite), fermorite, ellestadite, wilkeite, mangan-apatite and collophane (including quercyte) were examined by *x*-ray methods and were found to produce powder diagrams which differ from one another but slightly. The chemical analyses of these minerals indicate that calcium may be replaced by Na, K, Mn, Sr, Mg, and carbon. Phosphorus may be replaced by S, Si, As, V, and carbon; fluorine by chlorine and oxygen and by hydroxyl groups. The lattice dimensions of these minerals were determined and, whenever the analytical results seemed sufficiently reliable, the theoretical density was calculated and compared with the measured density.

This study has permitted certain conclusions regarding the nomenclature of these minerals and has resulted in an explanation of carbonate-apatites, alkali-apatites and oxy-apatite. All of these types of substitution can be explained in terms of the structure of fluor-apatite.

These substances are all members of various isomorphous series of the apatite group, but only in several instances have the end-members been discovered. Besides fluor-apatite the only ones known are hydroxy-apatite (1935) and ellestadite (1937). It is not possible to calculate the compositions of the end-members in most cases because some of the ions (C, OH, F, et al.) can enter the structure in more than one sort of ionic position and the relative distribution between the several positions may vary with the amount of the ion present. Furthermore, one type of ionic substitution may be mutually dependent upon another type, producing isomorphous mixtures of extreme complexity.

CLEAVAGE-LUMINESCENCE IN MICA

BY V. B. MEEN

Mica from Kilmar, Quebec, was found to luminesce when split. The optical properties and chemical composition were discussed. Certain other micas were found to show the same phenomenon.

HARMOTOME FROM DELAWARE COUNTY, PENNSYLVANIA, A BARIUM ZEOLITE OF HYDROTHERMAL ORIGIN

BY ADOLPH E. MEIER AND W. HAROLD TOMLINSON

Small creamy white to transparent cruciform penetration twins of harmotome were found lining the joint seams of a tongue of gabbroid rock in serpentine near Glen Riddle, Pennsylvania. Identity of the mineral was confirmed by optical measurements and chemical analysis. Closer study of the rock exposure revealed an interesting suite of associated minerals such as barium potash feldspars, corundum, and montmorillonite.* The results of the study indicate a fairly low temperature, hydrothermal origin for the harmotome.

The paper was divided into two parts. The first part gave a brief description of field and petrographic relationships necessary for an understanding of the discussion of the paragenesis of the harmotome which followed. The second part covered optical and crystallographic measurements, and chemical analysis of the harmotome. Data obtained on loss of water with heating, with attendant changes in optical properties, were also included. The bearing of the latter on the possible formation temperature of the harmotome was also discussed briefly. On the whole the general properties of the mineral seem to be within the limits of variation of data obtained on harmotome from other localities.

* Montmorillonite has been discussed in the November, 1937 issue of *The American Mineralogist*. Origin of the corundum will be treated in a future paper.

GENESIS OF CERTAIN ADIRONDACK GARNET DEPOSITS

BY WILLIAM J. MILLER

The garnet deposits discussed in this paper occur in northwestern Warren County, New York, and adjacent regions.

Twenty-five years ago the writer advocated a theory according to which the garnets were produced by action of quartz syenite magma upon inclusions of basic Grenville gneiss. This theory needs to be modified. The garnets with conspicuous reaction rims of hornblende seem to have been produced by action of quartz syenite magma upon metagabbro, and the garnets without reaction rims seem to have been produced by action of anorthosite magma upon metagabbro, followed by attack of the combination by syenite magma.

SULPHATE MINERALS OF THE COMSTOCK LODGE, NEVADA*

BY CHARLES MILTON AND W. D. JOHNSTON, JR.

The following sulphates have been identified in old mine workings of the Comstock Lode: gypsum, epsomite, copper-zinc-epsomite, goslarite, magnesia-goslarite, melanterite, zinc-magnesia-chalcanthite, pickeringite, coquimbite, alunogen, copiapite, voltaite, and rhomboclase. These minerals are being deposited in or above the Sutro Tunnel which drains the lode. Iron, copper, and zinc sulphates are deposited in or beneath veins containing hypogene pyrite, chalcopyrite, and sphalerite. No silver was found in the sulphates. Pickeringite and epsomite are most abundant in areas of highly altered wall rocks. Timbers on the Sutro Tunnel level are shredded by the growth of pickeringite and epsomite crystals between the wood fibers.

* Presented under the auspices of the Geological Society of America.

THE UNWEATHERED MANGANESE DEPOSITS OF THE
BATESVILLE DISTRICT, ARKANSAS†

BY H. D. MISER AND D. F. HEWETT

Since its discovery, about 1849, the Batesville district has been the source of a large quantity of manganese oxides that occurred in clays residual from the weathering of the enclosing Fernvale limestone (Ordovician). Since 1928, however, a considerable quantity of manganese carbonate and hausmannite has been mined and shipped from tabular lenses that lie parallel with the bedding and near the top of the enclosing Fernvale limestone and, therefore, close to the overlying Cason shale (Ordovician), which contains nodules (Girvanella) that are rich in manganese carbonate. Although they are largely manganese carbonate, some bodies contain considerable hausmannite, as well as bementite, and neotocite. Accessory minerals include hematite, pyrite, barite, and fluorite. The form and distribution of some small bodies of carbonate, as well as the larger bodies, that have been mined indicate that they are related to fractures that cut across the Fernvale limestone but, so far as known, do not extend into the overlying and underlying formations.

It has been known for many years that unweathered Fernvale limestone, even remote from bodies of manganese oxide or carbonate, contains appreciable manganese carbonate that was probably deposited with the limestone. It seems probable, therefore, that the concentrated bodies of manganese carbonate now being explored were formed by the concentration of the manganese disseminated through the Fernvale limestone, although at present exotic sources cannot be completely dismissed. The widespread presence of bementite, which is only known in deposits of hydrothermal origin, as well as neotocite, barite, and fluorite, indicates that the waters that accomplished this concentration were warm rather than cold. Their source is obscure.

* Published by permission of the Director of the Geological Survey, United States Department of Interior.

† Presented under the auspices of the Society of Economic Geologists.

CRYSTAL STRUCTURE AND DENSITY OF DELAFOSSITE

BY ADOLF PABST

Ramdohr (*Zentralblatt für Mineralogie* (A) pp. 289–303 (1937)) has taken the structure of delafossite, CuFeO_2 , to be identical with that of artificial cuprous ferrite determined by Soller and Thompson (*Phys. Rev.*, vol. 47, p. 644 (1935)).

The structure belongs to the space group $D_{3d}^5-R\bar{3}m$. The unit rhombohedron, $a = 5.96 \text{ \AA}$, $\alpha = 29^\circ 26'$, is assumed to contain one CuFeO_2 . Atomic coordinates are given as: Cu (0, 0, 0); Fe ($\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$); O ($1/9$, $1/9$, $1/9$) and ($-1/9$, $-1/9$, $-1/9$).

The density corresponding to this structure is 5.52, notably higher than the value 5.07 given for delafossite by Friedel.

The hexagonal cell corresponding to the rhombohedral cell of Soller and Thompson has an axial ratio of 5.645 or 3×1.882 . This compares with Roger's value, 1.94 (*Am. Jour. Sci.*, vol. 35, pp. 290-294 (1913)) obtained on crystals from Bisbee.

Interplanar spacings calculated from powder diffraction patterns of delafossite from Bisbee, Arizona, and from Kimberley, Nevada, as well as a powder pattern of delafossite published without interpretation by Waldo (*Am. Mineral.*, vol. 20, pp. 575-597 (1935)) agree nicely with spacings calculated from Soller and Thompson's cell for cuprous ferrite.

HEAVY MINERALS IN THE GRANITIC ROCKS OF THE YOSEMITE REGION

BY ADOLF PABST

A study of the minerals separated from granitic rocks of the Yosemite region by the use of heavy liquids revealed no unusual or unexpected constituents. In spite of the fact that all of the principal intrusives of the region have certain group characteristics in common, a few of the rock types may be clearly distinguished by differences in the assemblage of accessory minerals.

The examination of basic inclusions for their accessory minerals again suggests a close genetic relation to the host rocks. No explanation of this is offered.

YEATMANITE, A NEW MINERAL, AND SARKINITE FROM FRANKLIN, NEW JERSEY

BY CHARLES PALACHE, L. H. BAUER, AND HARRY BERMAN

Yeatmanite, $(\text{Mn}, \text{Zn})_{16}\text{Sb}_2\text{Si}_4\text{O}_{29}$, is a new mineral from Franklin, N. J. It is triclinic, pseudo-orthorhombic, with multiple twinning on $b(010)$ and macroscopic twinning on (023) . Elements (x -ray): $a:b:c=0.7811:1:0.4775$. $\alpha=103^\circ 49'$; $\beta=101^\circ 45'$; $\gamma=87^\circ 12'$. Cleavage perfect $\parallel (100)$; H. 4, G. 4.80. Biaxial, negative; X near $a[100]$, Y near $b[010]$, $Z \wedge c[001]=3\frac{1}{2}^\circ$. Indices (Na): $nX=1.873$, $nY=1.905$, $nZ=1.910$, all ± 003 . $2V$ about 49° , $r < v$, dispersion moderate. Clove-brown crystalline plates embedded in willemite.

WAVE SURFACES AND INDICATRICES

BY A. L. PARSONS

A graphical representation of the reciprocal relations between wave velocity and indices of refraction in air, isotropic substances, uniaxial and biaxial crystals. By the use of reciprocal circles and ellipses the indicatrix of biaxial crystals is shown to have a form similar to the wave surface with the optic axes emerging at the little depression where the circle representing β meets the ellipse whose semi major and semi minor axes are γ and α .

GOLDSCHMIDTINE, A NEW ANTIMONIDE OF SILVER

BY M. A. PEACOCK

System and morphological lattice, orthorhombic— C ; $a:b:c=0.6312:1:0.6860$. Thirteen forms. Habit, stout prismatic $[001]$, pseudo-hexagonal, with dominant forms, $c\{001\}$, $b\{010\}$, $m\{110\}$. Twinning, on (110) , in all crystals. Structural lattice, orthorhombic— C ; $a_0=7.75 \pm 0.05 \text{ \AA}$, $b_0=12.32 \pm 0.05 \text{ \AA}$, $c_0=8.42 \pm 0.05 \text{ \AA}$; $a_0:b_0:c_0=0.629:1:0.683$; $V_0=804$ cubic \AA . Specific gravity, 6.83 ± 0.03 . $M_0=3328$. The base-centered cell contains $\text{Ag}_{20}\text{Sb}_{10}$. Cleavage, none. Hardness, $2\frac{1}{2}$. Scarcely sectile. Crystals tin-white to lead-gray; opaque. Polished surfaces homogeneous, tin-white, distinctly anisotropic. Analysis (Gonyer): Ag 64.78, Sb 35.01, S 0.06, Pb, As, Cu, Sn none=99.85. Composition Ag_2Sb . Occurs with

native silver, ruby silver and galena on a specimen from Andreasberg, Harz. Named in memory of Victor Goldschmidt (1853-1933) of Heidelberg. Goldschmidtine differs in all its essential properties from those reliably determined on dyscrasite— Ag_3Sb .

DIRECT PROJECTION OF OPTICAL FIGURES*

BY TERENCE T. QUIRKE

A detachable stage holding a semi-translucent hemispherical surface permits reading of optical angles ($2E$), and orientation of mineral grains by inspection. The attitude and azimuth of optic axes may be read from vertical and horizontal scales upon the hemisphere of projection. Projection is achieved by the use of a polaroid plate in the base of the accessory stage placed over a mineral or rock slide, thus superposing a flat analyzer over the convergent polarized light from sub-stage illumination.

* Presented under the auspices of the Geological Society of America.

THE SYMMETRY, UNIT CELL, AND COMPOSITION OF HANKSITE

BY LEWIS S. RAMSDELL

Laue photographs of hanksite show the symmetry C_{6h} , hence the actual symmetry may be C_{6h} , C_6 or C_{3h} . Since the crystals are neither trigonal nor hemimorphic in development, C_{6h} would seem the most probable. The unit cell is a very large one. Oscillation photographs about the a , b and c axes, together with powder photographs, give the values $a = 10.46\text{\AA}$ and $c = 21.18\text{\AA}$, $a:c = 1:2.024$. This cell contains 2 molecules of $9\text{Na}_2\text{SO}_4 \cdot 2\text{Na}_2\text{CO}_3 \cdot \text{KCl}$.

NICKEL CONTENT OF AN ALASKAN TROCTOLITE†

BY JOHN C. REED

A troctolite sill about 126 feet thick lies in a thick sequence of greenstone schists, graphitic phyllites, and quartzites on Admiralty Island near Juneau, Alaska. Diorite or gabbro bodies are also present in the vicinity. The sill, called at the outcrop, the Mertie Lode, occupies a position near the crest of a large southeastward pitching anticline. The sill in its known extent is probably only a small part of a much larger body.

The sill is coarse grained, but has a diabasic texture. Measurements of volumetric proportions of the component minerals of the rock by means of traverses across thin sections show the rock, as represented by the thin sections, to contain about 62.3 per cent labradorite, 34.2 per cent olivine, 2.2 per cent pyroxene, 0.82 per cent pyrrhotite, 0.20 per cent magnetite, 0.13 per cent chalcopyrite and 0.06 per cent pentlandite.

The rock contains about 0.18 per cent chalcopyrite and 0.10 per cent pentlandite by weight. The copper content, therefore, is about 0.06 per cent and the nickel content about 0.025 per cent (the composition of pentlandite is not definite but the nickel content of that mineral used in the calculations was 24.65 per cent, which was the nickel content of pentlandite from a not far distant locality on Yakobi Island, analyzed by A. H. Phillips).

A chemical analysis by R. C. Wells of a panned concentrate from a chip sample of the sill showed $3\frac{1}{2}$ times as much copper as nickel. This appears to check within reasonable limits of error of sampling and petrographic measurements, the ratio of copper to nickel or about $2\frac{1}{2}$ to 1 obtained by petrographic measurements.

Assuming that the relative proportions of metallic minerals as determined petrographically is reasonably correct, then a mixture of the opaque minerals of the sill in those proportions, with no silicates, would contain only 1.4 per cent nickel.

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† Presented under the auspices of the Society of Economic Geologists.

ON TAR BUTTITE

BY WALLACE E. RICHMOND, JR.

Excellent crystals of tarbuttite, a basic zinc phosphate, from Broken Hill mines, Rhodesia, are triclinic: $a:b:c=0.6296:1:0.5971$; $\alpha=89^\circ 37\frac{1}{2}'$, $\beta=91^\circ 28\frac{1}{2}'$, $\gamma=107^\circ 41'$ (new elements derived from ten crystal measurements on the two-circle goniometer computed in the new position, the normal triclinic setting); twenty of the twenty-nine accepted forms were observed; also the new form $q\{\bar{1}02\}$ and the new but uncertain form $\{321\}$; ten reported forms were discredited; cleavage $\{010\}$ perfect; habit short prismatic approximating pseudo-isometric. X-ray measurements gave: $a_0=8.097 \text{ \AA}$, $b_0=12.91 \text{ \AA}$, $c_0=7.688 \text{ \AA}$; $\alpha=89^\circ 34\frac{1}{2}'$, $\beta=91^\circ 35\frac{1}{2}'$, $\gamma=107^\circ 47'$; $a_0:b_0:c_0=0.6271:1:0.5957$. The pseudo-isometric lattice is a multiple lattice of the proper crystal lattice. From existing analyses and densities the unit cell contains $8[\text{Zn}_2\text{PO}_4(\text{OH})]$.

New optical data:

	ϕ	ρ	$n(\text{Na})$	
$X(\text{colorless})$	7°	58°	1.660	Positive $\pm 0.003 \text{ } 2V=50^\circ \pm 2^\circ$
$Y(\text{colorless})$	-159	25°	1.705	
$Z(\text{colorless})$	-86	80	1.713	

DIADOCHITE, A MINERALOID FROM THE NEW IDRIA MINE,
SAN BENITO COUNTY, CALIFORNIA

BY AUSTIN F. ROGERS

A yellow-brown, resin-like, massive material found in an old fill of one of the drifts of the New Idria quicksilver mine proves to be amorphous, and so is called a mineraloid.

Chemical analyses reveal that it is a hydrous ferric sulfate-phosphate, analogous to the corresponding sulfate-arsenate, pitticite, which is a more common mineraloid.

A quantitative analysis leads to the formula: $2\text{Fe}_2\text{O}_3 \cdot 3(\text{SO}_3, \text{PO}_3) \cdot 15\text{H}_2\text{O}$, which is surprisingly definite for a mineraloid.

This is apparently the first American occurrence of diadochite (phosphoreisensinter)

MEROSYMMETRY VERSUS MEROHEDRISM

BY AUSTIN F. ROGERS

Although Groth's names of crystal classes based upon general forms are superior to other names, it is often convenient to refer to the class with the maximum symmetry in any system and also to classes of lower-grade symmetry.

For this purpose the terms holohedral and merohedral have usually been used. The merohedral forms (hemihedral, tetartohedral, etc.) are said to be produced from the holohedral forms by suppression of certain faces and the extension of others.

Since the suppression of faces is always a *symmetrical* suppression, it seems advisable to substitute the suffix *-symmetric* for the suffix *-hedral*. Thus we have holosymmetric, merosymmetric, hemisymmetric, etc. (Symmetry is the key-note in the study of crystals.)

These terms were introduced by Story-Maskelyne in 1875 and elaborated upon in his classic, "Crystallography, a Treatise on the Morphology of Crystals" (1895). Story-Maskelyne's nomenclature of the crystal classes, however, is unnecessarily complicated.

A simple set of names based upon merosymmetry was presented as a list supplementary to class names based upon general forms.

QUARTZ WITH PINAKOID FACES FROM NATHROP,
CHAFFEE COUNTY, COLORADO

BY AUSTIN F. ROGERS AND LAZARD CAHN

Minute α -quartz crystals of prismatic habit with the forms $\{10\bar{1}0\}$, $\{20\bar{2}1\}$, $\{02\bar{2}1\}$, $\{10\bar{1}1\}$, $\{01\bar{1}1\}$, $\{20\bar{2}3\}$, $\{02\bar{2}3\}$, and $\{0001\}$ from Ruby Mtn., Chaffee County, Colorado,

show very prominent pinakoidal faces. This is one of the very few authentic occurrences of the pinakoid on quartz.

**AN OPTICAL ANALYSIS OF IMMERSION METHODS WITH REFERENCE
TO THE SENSITIVITY OF THE DOUBLE-DIAPHRAGM METHOD**

BY CHARLES P. SAYLOR

Employing monochromatic light and the double-diaphragm method of oblique illumination, a difference of 0.00015 between the refractive index of a particle and an immersion liquid can be seen without difficulty (*J. Research NBS* 15, p. 277 (1935); RP 829). This results in a sensitivity in the determination of refractive indexes that cannot be attained in practice with the ordinary method of oblique illumination or with central illumination. An analysis of the optical mechanisms involved in image formation under these circumstances makes clear the reasons for the greater sensitivity and emphasizes the importance of adjusting the condenser diaphragm vertically so that its image is strictly in the plane of the objective diaphragm.

AN OCCURRENCE OF LARGE HALITE CRYSTALS

BY CHESTER B. SLAWSON

Rock salt is mined at Detroit from a continuous seam of horizontally stratified salt. Large masses of clear transparent halite crystals are occasionally encountered. These masses average from ten to fifteen feet across and are associated with lenses of fine dense dolomite which generally lie beneath the halite crystals. Single crystals two feet or more in diameter are not uncommon. In many instances blasting has caused the separation of crystals along the dodecahedral gliding plane to be more extensively developed than separation along the cubical cleavage. While these masses occur throughout the mine they are most frequently found along two zones of alignment.

**MODELS TO AID IN VISUALIZING THE OPTICAL
PROPERTIES OF CRYSTALS**

BY HAROLD T. U. SMITH

By means of transparent celluloid models, the following relations are illustrated: (1) orientation of the uniaxial indicatrix in hexagonal and tetragonal crystals, as shown by wooden ellipsoids inclosed in crystal models; (2) orientation of the biaxial indicatrix in orthorhombic and monoclinic crystals, similarly shown; (3) vibration directions in an orthorhombic crystal; (4) the uniaxial indicatrix in skeleton form; (5) the biaxial indicatrix in skeleton form; (6) the relation of the uniaxial indicatrix to the ray-surfaces, in three mutually perpendicular cross sections; (7) the relation of the biaxial indicatrix to the ray-surface, in the three principal sections.

**ORIGIN OF FIBROUS GYPSUM VEINS IN THE LYKINS AND
MORRISON FORMATIONS OF COLORADO**

BY LINCOLN R. THIESMEYER

Near Table Mountain, eighteen miles southwest of Colorado Springs, veins of fibrous gypsum are locally abundant in the Lykins and Morrison formations. Three types of veins are distinguished, as follows: one group of cross-fiber veins forms subparallel networks within a massive alabaster member of the Morrison, and roughly parallel to its bedding; another set of cross-fiber veins crosses these and extends downward into lower members of the Morrison and into the Lykins redbeds; a third set follows the bedding-planes of arenaceous red shales in the Lykins. The gypsum of this third set varies from fibrous to

lamellar, but the elongation of the crystals is roughly parallel to the dip of the beds, so that the grains lie almost parallel to the vein walls. The veins contain partings of shale and display most of the features common to fibrous veins elsewhere. Their restriction to the central portions of small, local, anticlinal structures indicates that they were formed subsequent to the regional deformation and followed fractures resulting from it. Limitation of the veins to a stratigraphic position everywhere within or below massive beds of gypsum in the Morrison suggests that the latter supplied the vein material to downward-migrating groundwaters. Several lines of evidence indicate that the fibrous structures are not a result of lateral secretion through the wallrocks, as has been proposed for many fibrous mineral occurrences. Similar phenomena and conclusions were reported for fibrous gypsum veins observed near Rapid City, South Dakota.

HEAVY MINERAL METHODS APPLIED TO THE PRE-CAMBRIAN ROCKS OF THE SOUTH SHORE OF LAKE SUPERIOR*

BY STANLEY A. TYLER AND RALPH W. MARSDEN†

On the south shore of Lake Superior, pre-Huronian and Keweenaw igneous rocks may be readily distinguished by the variety of zircon present. A third period of intrusion, post-Huronian-pre-Keweenaw, is postulated and it is thought that rocks of this age may be distinguished from those of the other two periods. The pre-Huronian rocks are characterized by a purple zircon similar to those described by Mackie from the pre-Cambrian of Scotland. The post-Huronian-pre-Keweenaw rocks are characterized by a weakly birefringent zircon, and those of Keweenaw age by a euhedral, colorless to yellow zircon. The date of unroofing of these batholithic intrusions is clearly shown in the associated sediments.

The study of the heavy accessory minerals in the Keweenaw igneous rocks shows that the relative percentage of the minerals change with the rock type and for this reason relative percentages cannot be used as a basis for correlation. The variety of zircon remains essentially constant regardless of the composition, or the crystallization and cooling history of the rock.

The detrital heavy mineral suite in the Huronian sediments remains remarkably constant throughout, therefore individual formations cannot be distinguished by heavy mineral methods. However, a heavy mineral study may be used to distinguish Huronian sediments from those of Keweenaw age in this area.

A re-study of the Upper Keweenaw series of Wisconsin has been made and a revision of the sequence advanced, which is conformable with the field occurrence and the heavy mineral studies. The heavy minerals may be used to distinguish the Oronto from the Bayfield group.

* Presented under the auspices of the Geological Society of America.

† Introduced by A. N. Winchell.

A PYROPHYLLITE DEPOSIT IN SOUTHEASTERN NEWFOUNDLAND*

BY J. S. VHAY†

Quartz-pyrophyllite schists occur in an area near Manuels, on the south side of Conception Bay, southeastern Newfoundland. The pyrophyllite has been formed by the hydrothermal alteration of sheared and silicified rocks of the pre-Cambrian Harbour Main volcanics, near a granite contact; the volcanics here consist of rhyolite flows and some clastic material.

The schists consist of various proportions of quartz and pyrophyllite, and grade into large masses of nearly pure pyrophyllite; they exhibit a variety of textures, depending

upon the structures of the original rocks. The typical quartz-pyrophyllite schist has quartzose nodules in a matrix of pyrophyllite. Thin sections show coarse pyrophyllite along fractures, and a mat of fine pyrophyllite replacing both the original minerals and the secondary quartz. The flakes of pyrophyllite have a random orientation, and the schistosity is an inherited structure preserved by differential replacement on the planes of schistosity.

Three factors influenced the localization of the pyrophyllite, (a) the acidic composition of the host rock, (b) the sheared condition of the rock, which itself depended in part upon the original structures of the flows; the schistosity was best developed in the flow-banded, spherulitic, and flow-brecciated types of rhyolite rather than in the massive type; because of these factors the schists high in pyrophyllite tend to lie in elongated areas parallel to the strike of the flows, (c) proximity to fissures near the granite contact, which acted as channelways for the hydrothermal solutions.

* Published by permission of the Government Geologist, Newfoundland Department of Natural Resources.

† Presented under the auspices of the Society of Economic Geologists.

‡ Introduced by T. B. Nolan.

OPTICAL METHODS OF MEASURING IN REFLECTED POLARIZED LIGHT (M. BEREK)

BY H. W. ZEILER

Microscopical analysis of opaque ores and minerals in reflected polarized light is generally confined to qualitative observations such as the color of the reflected light or the degree of anisotropism. M. Berek, a few years ago, developed a method of measuring photometrically the power of reflection of opaque minerals. However, a general method for determining optical "parameters" of such minerals—similar to the methods available for transmitted polarized light where optical character, birefringence, angle between the optical axes, etc., can be determined—did not exist for reflected polarized light. Even determinations of the directions of vibration were subject to grave errors because the equipment available did not produce sufficiently well-defined, homogeneous, plane polarized light.

Recently the equipment was improved, so that plane polarized light of the highest purity and of one single azimuth can be produced in the plane of the specimen. These improvements permitted the development of methods of determination of the effects of anisotropism in reflected polarized light. The measurements are carried out with a rotating mica compensator and a rotating analyzer. M. Berek succeeded in defining various optical "parameters" of opaque minerals which show sufficient differentiation for diagnostic purposes. Berek has published various articles and one booklet about this subject and the speaker presented a brief review of the contents of these publications and demonstrated the new equipment.

The basic principle of these measurements in reflected polarized light is as follows: Due to the optical character of the mineral, the light which is reflected from its surface becomes elliptically polarized with a simultaneous rotation of the main axis of vibration in respect to the plane of vibration of the incident polarized light. The mineral is brought into two successive diagonal positions, whereupon the mica compensator measures the ellipticity of the reflected polarized light and the analyzer measures the angle of rotation of the main axis of vibration. These measurements are utilized for certain computations and lead to the determination of the optical symmetry (uniaxial or biaxial), the complex optical character, and other "parameters" pertaining to the mineral under investigation which lead to its diagnosis.

ATOMIC PACKING MODELS OF SOME COMMON SILICATE STRUCTURES

BY J. E. DORRIS, CLIFFORD FRONDEL, W. C. GÜSSOW, V. M. LOPEZ,
C. S. LORD, WILLIAM PARRISH, J. A. SHIMER

(See *Am. Mineral.*, vol. 23, pp. 65-84, 1938)

Data was presented for the construction of atomic packing models of zircon, olivine, diopside, muscovite and sanidine structures. Pertinent structural facts needed in calculating atomic bonding directions, together with instructions for assembling the models were outlined. Figures illustrating the various types of oxygen-sharing in the silica chains were given. Atomic packing models are helpful in the study of gliding, coordination, exsolution, isomorphism, cleavage, the relation between crystal structure and habit, and other problems in which a knowledge of the atomic positions, relative sizes and packing are essential. The "nuclear" models are largely restricted to show the symmetry and point positions and convey no idea of the relative atomic radii.

THE UNIT CELL AND SPACE GROUP OF TOURMALINE (AN EXAMPLE OF THE INSPECTIVE EQUI-INCLINATION TREATMENT OF TRIGONAL CRYSTALS)

BY M. J. BUEGERER AND WILLIAM PARRISH

(See *Am. Mineral.*, vol. 22, pp. 1139-1150, 1937)

The inspective equi-inclination treatment of hexagonal crystals was outlined. The lattice type may be easily determined by inspecting an appropriate *n*-level equi-inclination photograph. Two previous investigations have assigned tourmaline to space groups based upon a hexagonal lattice, but this study shows it to be based upon a rhombohedral lattice. Cell data for tourmaline from the Etta Mine, South Dakota, are as follows:

Diffraction symbol:	32/m R3 — —	
Lattice:	rhombohedral	
Crystal class:	C _{3v}	
Space group:	C _{3v} ⁵ , R3m	
Cell dimensions:	rhombohedral	referred to simplest hexagonal cell
	$a = 9.500 \text{ \AA}$	$A = 15.928 \text{ \AA}$
	$\alpha = 66^\circ 15'$	$C = 7.151 \text{ \AA}$
		$\frac{C}{A} = 0.4490$
Formula weights per cell:	1	3

It is estimated that more than 250 attended the various sessions of the Society. The following were present at the annual meeting:

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 1934 Rochester, New York
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The Chichitsu Chosasho (Geological Institute), South Manchuria Railway Company, Dairen, Manchuria.
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PROCEEDINGS OF SOCIETIES

NEW YORK MINERALOGICAL CLUB

American Museum of Natural History, New York City, December 15, 1937

The meeting was called to order by first Vice-President Dr. Olaf Andersen with 52 members and guests present. Dr. Philip Krieger then spoke to the Club upon some "Observations during the International Geologic Congress in Russia."

The Congress meets every three or four years, in various parts of the world. The last convention in Russia was some 40 years ago, and at the present gathering a number of the same localities were visited. At the conclusion of the Congress observation trips were arranged, and those with special interests had an opportunity to observe the work in their own field.

During the Congress itself a novel plan was instituted, eliminating the language difficulty. All in attendance wore earphones, and were connected to translators. An address delivered in any one of six languages was simultaneously translated by interpreters, so that everyone attending the Congress was fully aware of the proceedings. All that was necessary was to plug in on the proper hook-up.

The mines and mining industries are owned by the government and are operated by mining trusts, under the supervision of the Soviet. The greatest disappointment was the appearance of the Ural Mountains. Instead of the tall, rugged peaks and ranges expected, they turned out to be, for the most part, low hills, similar to those of Connecticut. Only the extreme northern and southern portions were "respectable mountains." A brief outline of the mines and minerals observed during the course of the field trips follows:

Chromite:—At Mt. Saranovskoye the chromite occurs as lenses in the peridotites (altered to serpentine). They are bordered on the west by paleozoic schists and on the east by metamorphosed diorite. Later dikes have cut the chromite lenses into a number of segments. The deposit is about 800 meters long and an estimated 150 meters deep. The ore averages between 32 and 38 per cent Cr_2O_3 , with iron and aluminum running high. Associated minerals are clinocllore, uvarovite, fuchsite and a chrome-perovskite.

Iron:—A number of localities were visited. Mt. Blagodatskiy, discovered in 1735, is of the typical contact metamorphic type, carrying garnet, epidote, scapolite, etc. The ore here is primarily magnetite, with a large portion of hematite (martite), which is secondary. About 300,000 tons is the yearly production.

The Mt. Vysokaya deposit was discovered in 1702. This is the second largest deposit in the Urals and is similar to that of Mt. Blagodatskiy. About 1,000 tons of concentrates are produced daily. A number of other iron mines in this district are in operation. The entire yearly output of iron from this section is about 8 million tons. In the Bakal Area other types of iron ore are mined. These are siderite and limonite. About a half million tons are produced annually. At Magnetogorsk are located the largest iron mines and steel plants in the Urals. The ores are similar in formation and type to those near Blagodatskiy and Vysokaya. The mine produces some five and half a million tons of ore annually. Only the oxidized ores are being mined as the primary ores contain up to 6% sulphur.

Platinum:—Near Nizhny Taguil we find a series of ultra basic igneous rocks (dunite and peridotite). Here a number of pits show platinum bearing dunites, with associated chromite. This lode material is low grade and is not being worked. To the north the placer deposits are being operated. Here American made dredges, each with a capacity of 350 cubic yards per hour, are functioning, reworking gravels that had previously been mined by hand, and again by steam shovel. The gravels yield from 30 mg. to 1.5 gr. per cubic meter. There are large areas yet to be worked.

Asbestos:—Russia is singularly fortunate in having good deposits of asbestos. At Bazhenov (about 85 kilometers northeast of Sverdlovsh) is located the main asbestos bearing belt, about 28 kilometers long and a full kilometer wide. Estimates give Russia an asbestos reserve of 25 million tons. At this locality the asbestos is associated with serpentine intrusive rocks and the asbestos belts seem to be related to the fracture zones. The quality of the mineral is excellent, the fibres reaching a length of 80 mm. Discovered in 1825, the deposit was first exploited in 1899 and is in active production today. A considerable quantity is exported. Mining is mainly by the open pit method, although recent operations have been underground.

Gold:—East of Sverdlovsh, formerly known as Ekaterinburg, are located the Berezhovsk gold deposits. The gold is low grade and is found in very thin, flat quartz veins, which occur in great profusion. These are associated with quartz porphyry dikes. Only the oxidized ores are being worked, as the primary ores were admittedly too lean to pay.

Magnesite:—Satka, (near Ufa) is the site of an enormous deposit of pure magnesite. The mineral occurs as a replacement in limestone and is the main source of magnesite in Russia. Open cut methods of mining are used, with a full complement of machine and electrical units. The annual production is about 6 million tons, and much of the material is exported to England, France and Germany. The beds are up to 80 meters thick, and the estimated reserve is about 145 million tons.

Coal:—The only coal deposit visited was the Koskino deposit at Cheliabush, south of Sverdlovsh. Low grade sub-bituminous coal is produced. Most of the foundries and steel plants in the Urals are supplied by this mine.

Nickel:—The need for this metal has caused intensive preparations for mining at Kalilova, near Orsh, in the southern Urals. The ore is composed of garnierite and a nickel-bearing chalcedony, disseminated through the weathered serpentine. The richest portion will average but 1.5% nickel.

Conclusions:—Russia is not particularly rich in metallic resources. Although some copper, zinc and lead are mined, a considerable quantity is imported. However, the Soviet has a large supply of the non-metallic minerals, and asbestos, magnesite, phosphate and manganese are shipped to other nations. Although industry has increased by leaps and bounds during the past 10 years (primarily with the aid of foreign technical assistance) the quality of much of the Russian ores is poor. The greatest advances in Russia today seem to be in the fields of science and education, where rapid strides are being made.

The interesting talk was well illustrated with lantern slides. The meeting adjourned at 9:50 P.M.

LEO NEAL YEDLIN, *Acting Secretary*

Meeting of January 19, 1938

The meeting was called to order by Second Vice-President H. R. Lee with 89 members and guests present. The speaker of the evening was Mr. Arthur Montgomery who addressed the Club upon "Four Seasons of Collecting."

Mr. Montgomery told how he had decided five years ago to collect mineral specimens of high quality and had contacted Edwin Over of Colorado Springs who had similar interests. Their first work was in the topaz locality of the Thomas Range, Utah, where fine, deep-colored crystals were collected from cavities in rhyolite. Their important contribution at this locality was the discovery of an occurrence of pseudobrookite in larger and finer crystals than any previously known from any locality. Finding a few needles on the slope of one of the peaks, Over traced them to their source where blasting revealed pockets containing the slender crystals.

Next they went to Devil's Head, a peak in the Front Range of the Rockies between

Denver and Colorado Springs, to investigate a locality at which a schoolboy had found a topaz crystal. Similar crystals had been found by a prospector many years ago. The discovery of some old, tree-grown dumps and a few emptied pegmatite pockets soon convinced them that they had rediscovered the lost locality. Intensive prospecting, followed by quarrying operations revealed a thin horizontal lens of pegmatite in the Rocky Mountain granite, parallel to the top of the ridge and only a few feet below the surface. Occasional bulges in the dike indicated the existence of pockets 18 inches to 2 feet below the surface of the contact. In these pockets crystals of smoky quartz, feldspar and topaz were found, embedded in red mud. After moving many tons of rock and overburden they found that the dike thinned out and became barren. About 25 or 30 good topaz crystals were secured, all more or less etched and showing interesting accessories.

More ambitious plans were made for the summer of 1935 and the San Diego Mine, at Mesa Grande, California, was leased in the hope of obtaining good tourmaline specimens. However, an incline sunk to a depth of 150 feet yielded practically nothing.

The summer of 1936 was more successful, with Montgomery and Over joining with Henderson and Ferguson on a trip to the epidote localities of Prince of Wales Island, Alaska, where many fine specimens were collected. Upon their return, Over and Montgomery stopped at an old variscite locality at Fairfield, Utah, where they collected some interesting specimens on the dumps and in an old drift. As the spot seemed very promising, they decided to commence their field activities there in the summer of 1937.

A lower drift had been tunneled into the hill in an endeavor to strike the nodule bearing zone of the limestone at a lower point, but their efforts were unsuccessful. After digging several branch drifts, Montgomery and Over struck the richest portion and were rewarded by finding a zone rich in the phosphate nodules. Most of them had altered completely to pseudowavellite but some were quite fresh. The variscite found was of very fine quality and color, as evidenced by the specimens on display, but still more interesting were the many rare minerals which are found only at this locality. Gordonite was found in fine crystals, colorless, white, pink and blue. Some brilliant specimens of wardite were also collected, and many other minerals still to be described.

They then moved to the vicinity of Butte, to try and locate a pegmatite on Timber Butte Hill from which two fine sphene crystals were known to have come. A quick survey showed the dike to be small and the pocket to have been probably the only one. They accordingly moved on to the Little Pipestone District to try to rework the old amethyst and tourmalinated quartz locality. Finding this dike, they cleaned out the old debris and discovered a large pocket in a quartz-rich portion which was lined with smoky quartz with later growths of amethyst. Some fine scepter crystals and parallel growths of the amethyst on portions of the smoky quartz were exhibited. Small brookite crystals were found with quartz in this pocket.

After the address, the Club adjourned to inspect the many beautiful specimens collected by Mr. Montgomery and to look over reprints of the papers describing the minerals collected on these trips.

F. H. POUGH, *Secretary*

NOTES

TEACHING FELLOWSHIP IN MINERALOGY

A teaching fellowship in mineralogy at Stanford University is now open to properly qualified graduate students who intend to specialize in mineralogy. Preference will be given to those who have had two years of graduate work. The chief duty of the fellow is to assist in laboratory instruction. Not more than eight or nine hours a week are required. The amount of the fellowship is \$750.

Application for the year 1938-39, accompanied by a photograph of the candidate and supported by testimonial letters, should be made to Professor Austin F. Rogers, Box 87, Stanford University, California.

A new journal has appeared recently in the field of mineralogy, *Zeitschrift für angewandte Mineralogie*, issued under the editorship of F. K. Drescher-Kaden of Cöttingen. Assisting in the editorial work are: G. Angenheister (Göttingen), P. J. Beger (Hannover), M. Berek (Wetzlar), C. W. Correns (Rostock), W. Eitel (Berlin-Dahlem), R. Nacken (Frankfurt a.M.), G. Masing (Göttingen), P. Ramdohr (Berlin), H. Rose (Hamburg), W. Schmidt (Charlottenburg), K. Spangenberg (Breslau) and H. Steinmetz (Munich). The issues will appear at irregular intervals with approximately four issues constituting a volume. The subscription price, if ordered in advance, is RM 28 for the volume. The first issue appeared Jan. 19, 1938.

CONFERENCE ON PETROFABRICS AT THE UNIVERSITY OF MICHIGAN

Dr. Earl Ingerson of the Geophysical Laboratory of the Carnegie Institution of Washington, D.C., will give a series of lectures to advanced students of geology and mineralogy on the technique and methods of interpretation of petrofabrics, from March 21 to March 28. The following lectures, accompanied by demonstrations, have been arranged:

March 21. What is petrofabrics?

March 22. Field and preliminary laboratory study. Measurement of uniaxial minerals.

March 23. Measurement of biaxial minerals; cleavage and twinning planes. Preparation and rotation of diagrams.

March 24. Orientation rules. Symmetry of diagrams.

March 25. Theories of schistosity.

March 26. Geologic applications.

March 28. Practical applications; summary.